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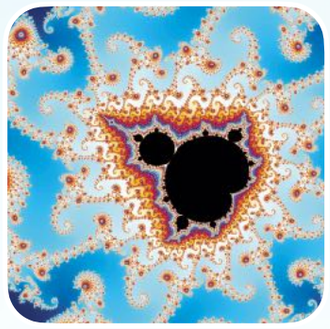


Creativity and Storytelling in Mathematics Education

Philipp Legner, @MathigonOrg
6 May 2020

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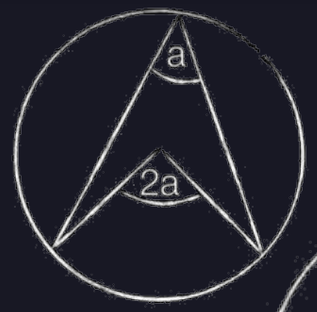
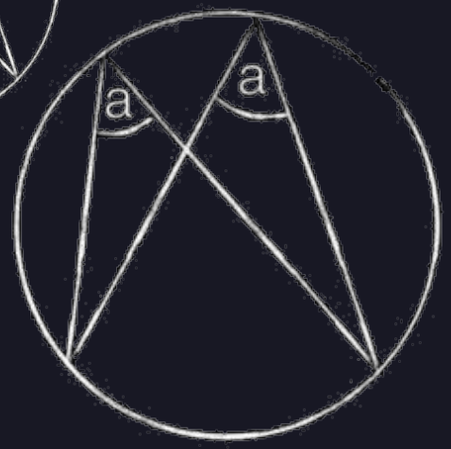
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$





SINE RULE

$$\frac{a}{\sin\hat{A}} = \frac{b}{\sin\hat{B}} = \frac{c}{\sin\hat{C}}$$

COSINE RULE

$$a^2 = b^2 + c^2 - 2bc \times \cos$$

OR $\cos A = \dfrac{b^2 + c^2 - a^2}{2bc}$

$$x^a \times x^b = x^{a+b}$$
$$(x^a)^b = x^{a \times b} = x^{ab}$$
$$x^a \div x^b = x^{a-b}$$

$$\frac{d}{dx}(\sinh(u)) = \cosh(u)\frac{du}{dx}$$

$$\frac{d}{dx}(\cosh(u)) = \sinh(u)\frac{du}{dx}$$

$$\frac{d}{dx}(\tanh(u)) = \operatorname{sech}^2(u)\frac{du}{dx}$$

$$\frac{d}{dx}(\coth(u)) = -\operatorname{csch}^2(u)\frac{du}{dx}$$

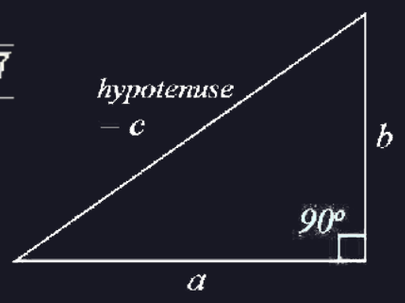
$$\frac{d}{dx}(\operatorname{sech}(u)) = -\operatorname{sech}(u)\tanh(u)\frac{du}{dx}$$

$$\frac{d}{dx}(\operatorname{csch}(u)) = -\operatorname{csch}(u)\coth(u)\frac{du}{dx}$$

$$\frac{d}{dx}(\sinh^{-1}(u)) = \frac{1}{\sqrt{u^2+1}}\frac{du}{dx}$$

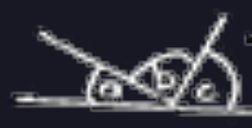
What is Mathematics all about?

$$\frac{12}{\sqrt{15}-\sqrt{7}} = \frac{12}{\sqrt{15}-\sqrt{7}} \cdot \frac{\sqrt{15}+\sqrt{7}}{\sqrt{15}+\sqrt{7}}$$
$$= \frac{12\sqrt{15}+12\sqrt{7}}{15-7}$$
$$= \frac{12\sqrt{15}+12\sqrt{7}}{8}$$
$$= \frac{3\sqrt{15}+3\sqrt{7}}{2}$$



$$c^2 = a^2 + b^2$$

$a+b+c = 180°$



$a+b+c = 180°$

$a+b+c+d = 360°$

sine

$\sin = \frac{o}{h}$

cosine

$\cos = \frac{a}{h}$

tangent

$\tan = \frac{o}{a}$

$A \cup B$: "A union B" i.e. A or B or both

$A \cap B$: "A intersection B" i.e. both A and B

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What is Mathematics all about?

Meaningful Mathematics

Art and Beauty

History of Mathematics

Puzzles, Patterns and Games

Understanding Nature and Science

Fiction

Useful Mathematics

Problem-solving

Critical Thinking

Creativity

Abstraction

Precision

Applications

Arithmetic + Algebra

Modelling + Simulation

Data Science

Cryptography

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Storytelling

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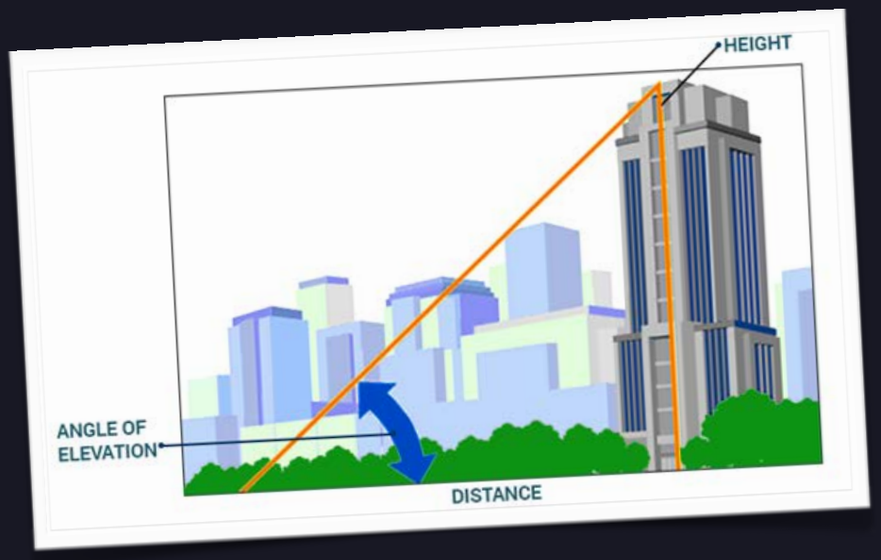
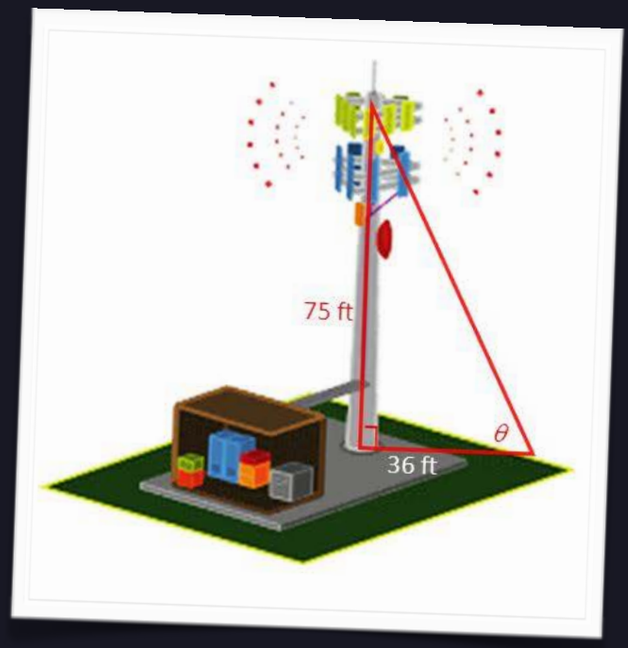
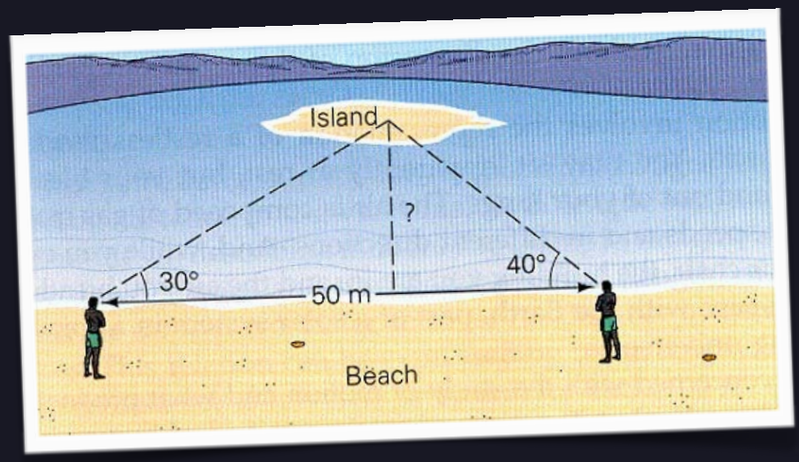
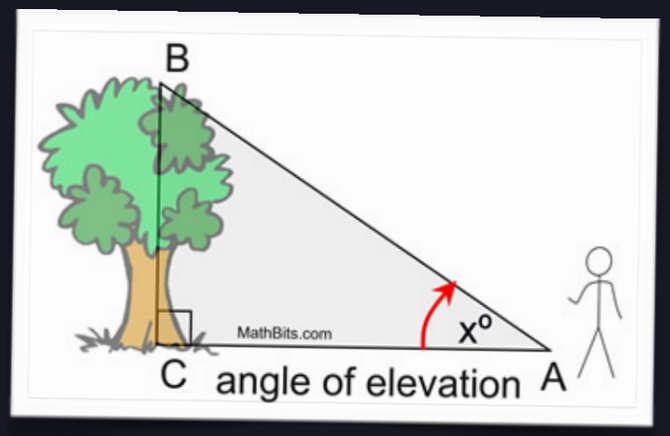
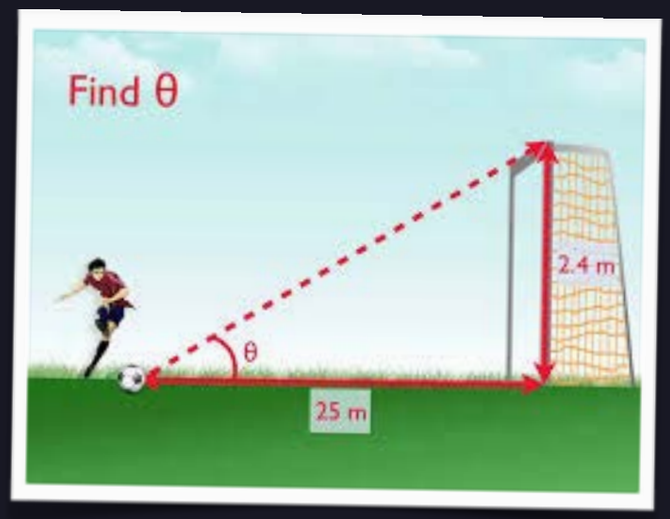
Trigonometry

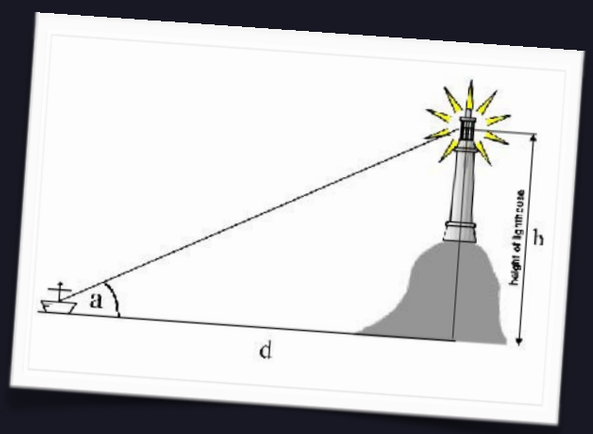


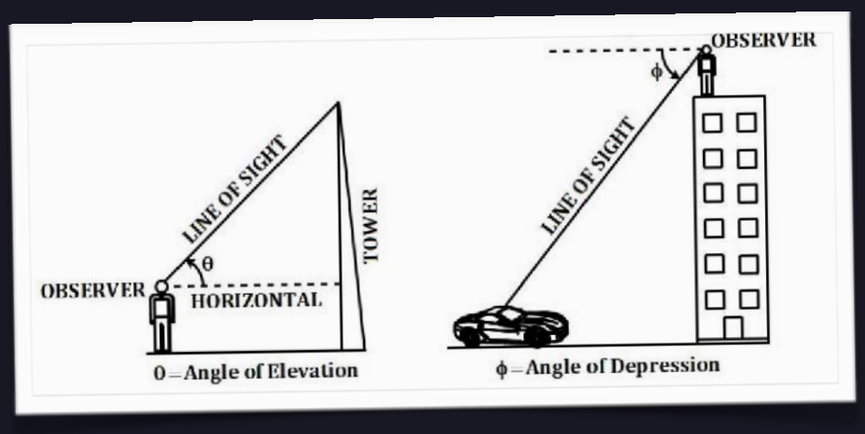


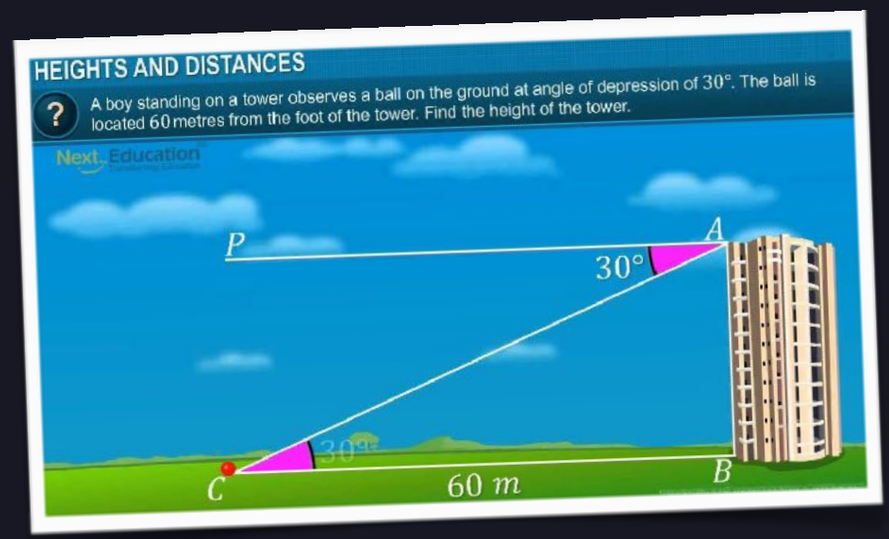


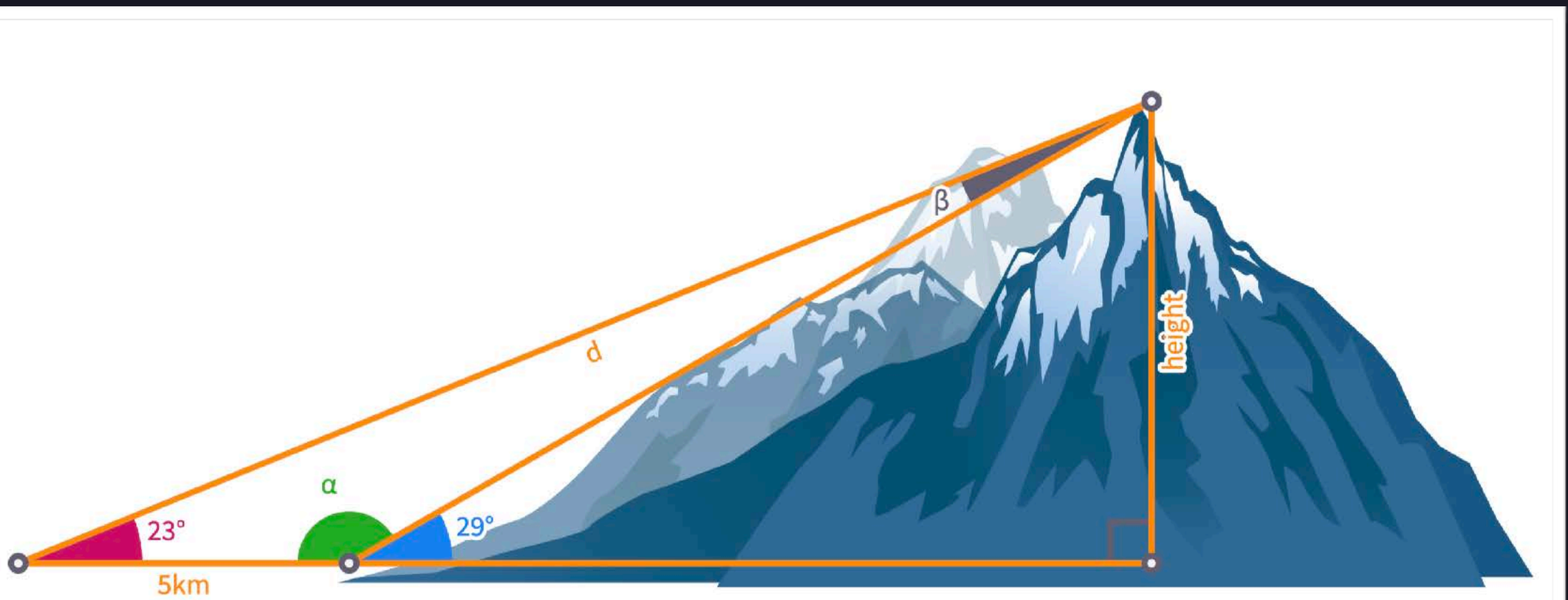












$$\frac{\sin 151°}{d} = \frac{\sin 6°}{5}$$

Trigonometry

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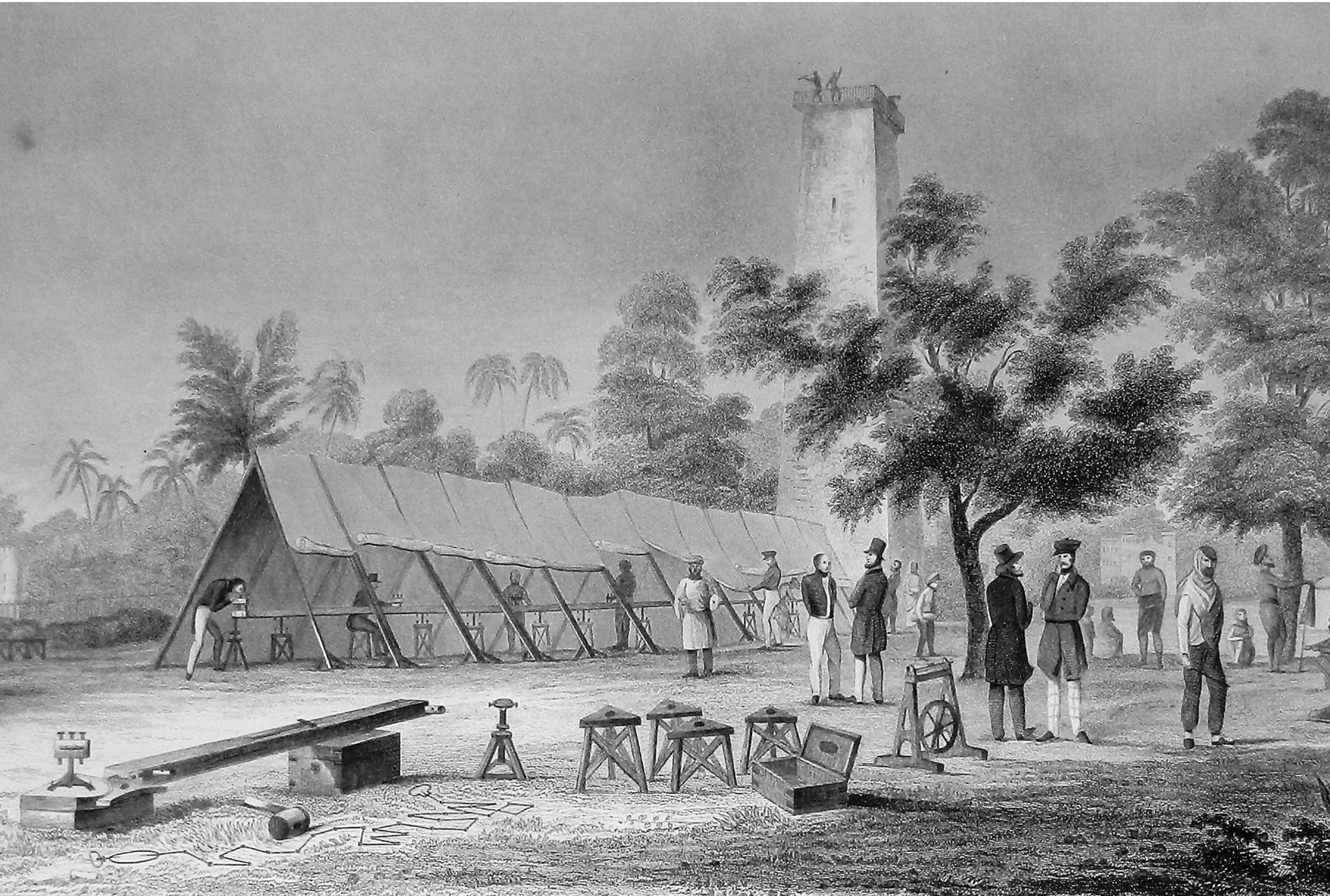
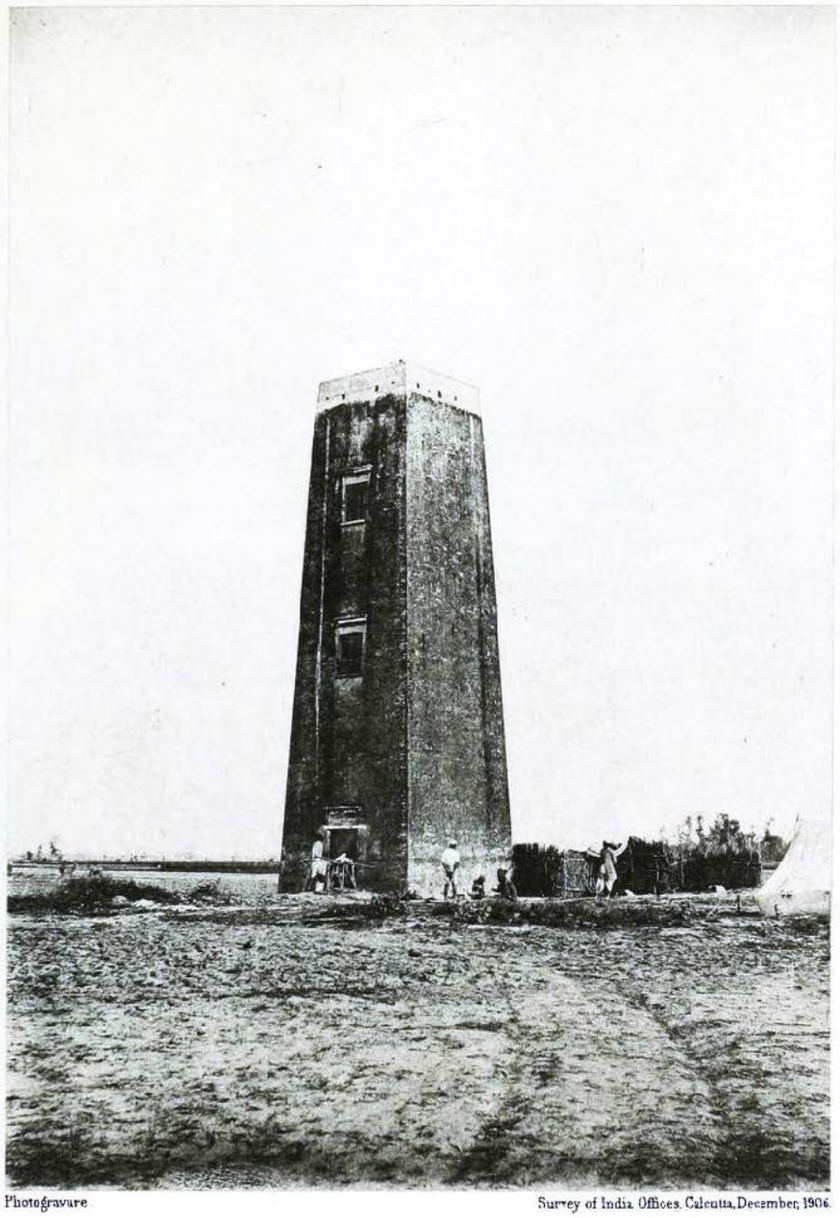
Mount Everest

INDEX CHART
TO THE
GREAT TRIGONOMETRICAL SURVEY
OF
INDIA

SHOWING COLONEL LAMBTON'S NET WORK OF TRIANGULATION IN SOUTHERN INDIA.
THE MERIDIONAL AND LONGITUDINAL CHAINS OF PRINCIPAL TRIANGLES,
THE BASE LINES MEASURED WITH THE COLBY APPARATUS,
THE LINES OF THE SPIRIT LEVELLING OPERATIONS,
THE ASTRONOMICAL PENDULUM & TIDAL STATIONS.



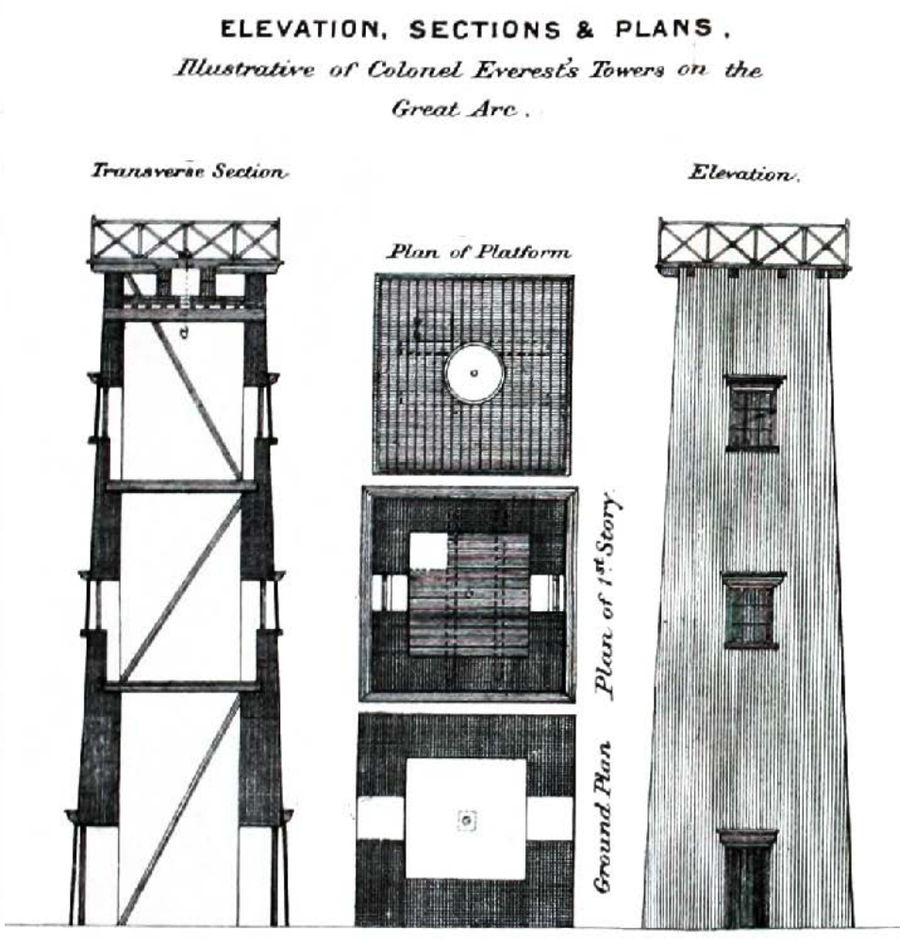


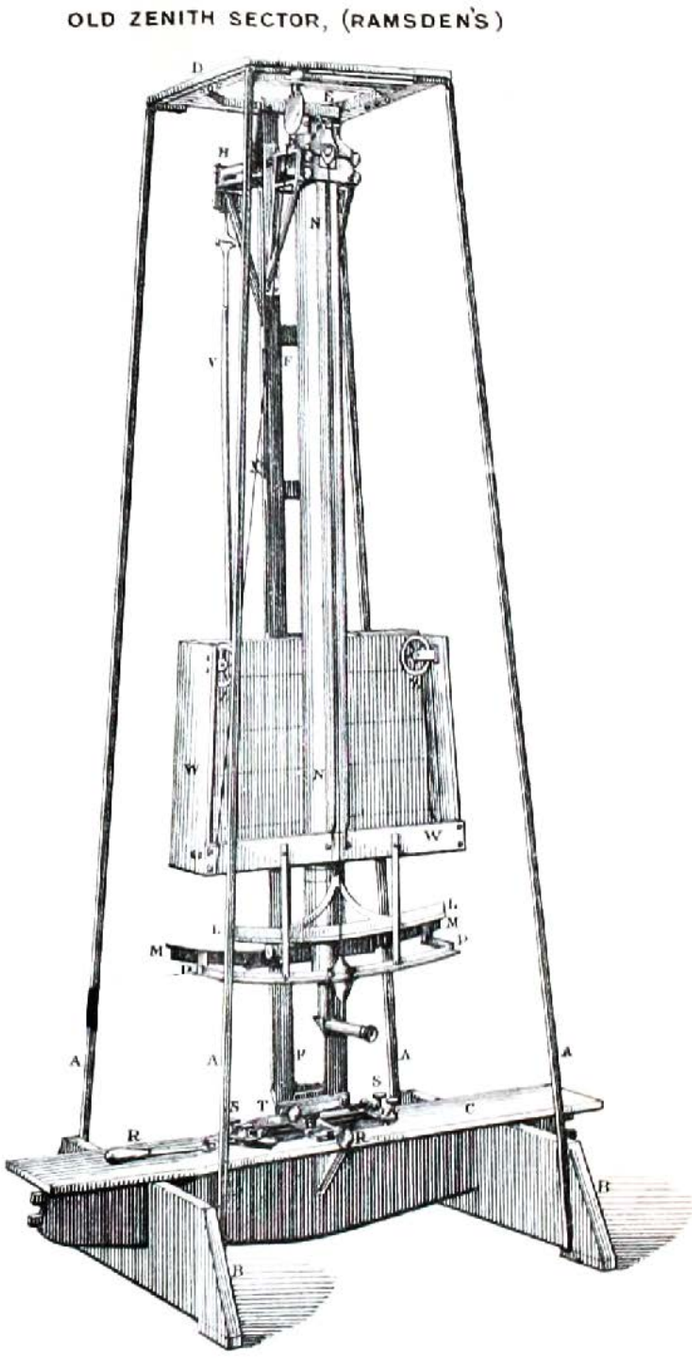
Photogravure — Survey of India Offices, Calcutta, December, 1906.

NOJLI TOWER.

A STATION OF THE GREAT TRIGONOMETRICAL SURVEY BUILT IN THE PLAINS OF UPPER INDIA NEAR ROORKEE AND FROM WHICH THE HIMALAYAN PEAKS OF BADRINATH, KEDARNATH, JAONLI AND BANDARPUNCH HAVE BEEN OBSERVED

FROM A PHOTO BY C.C. SIMONS.





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Radhanath Sikdar

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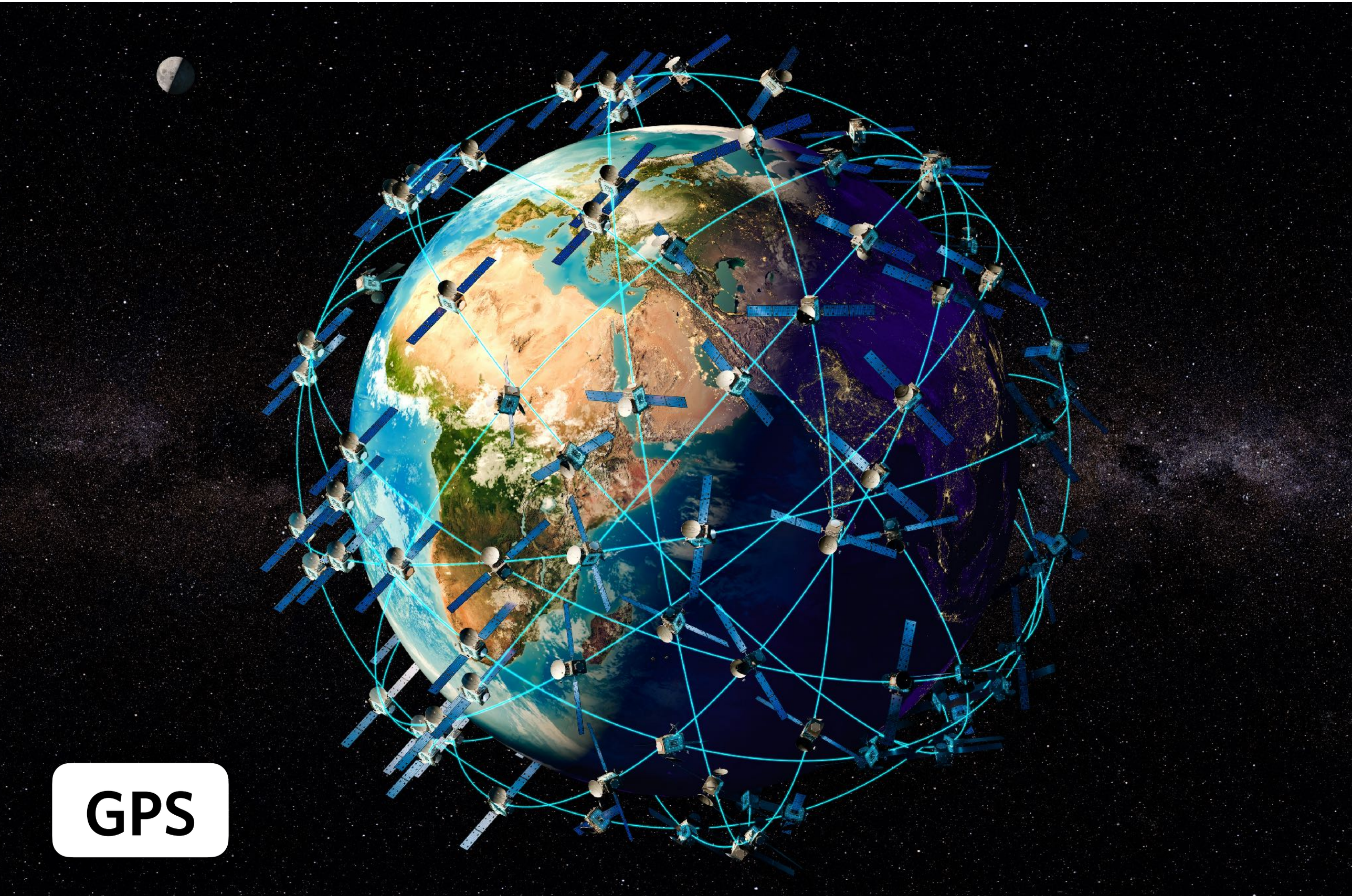
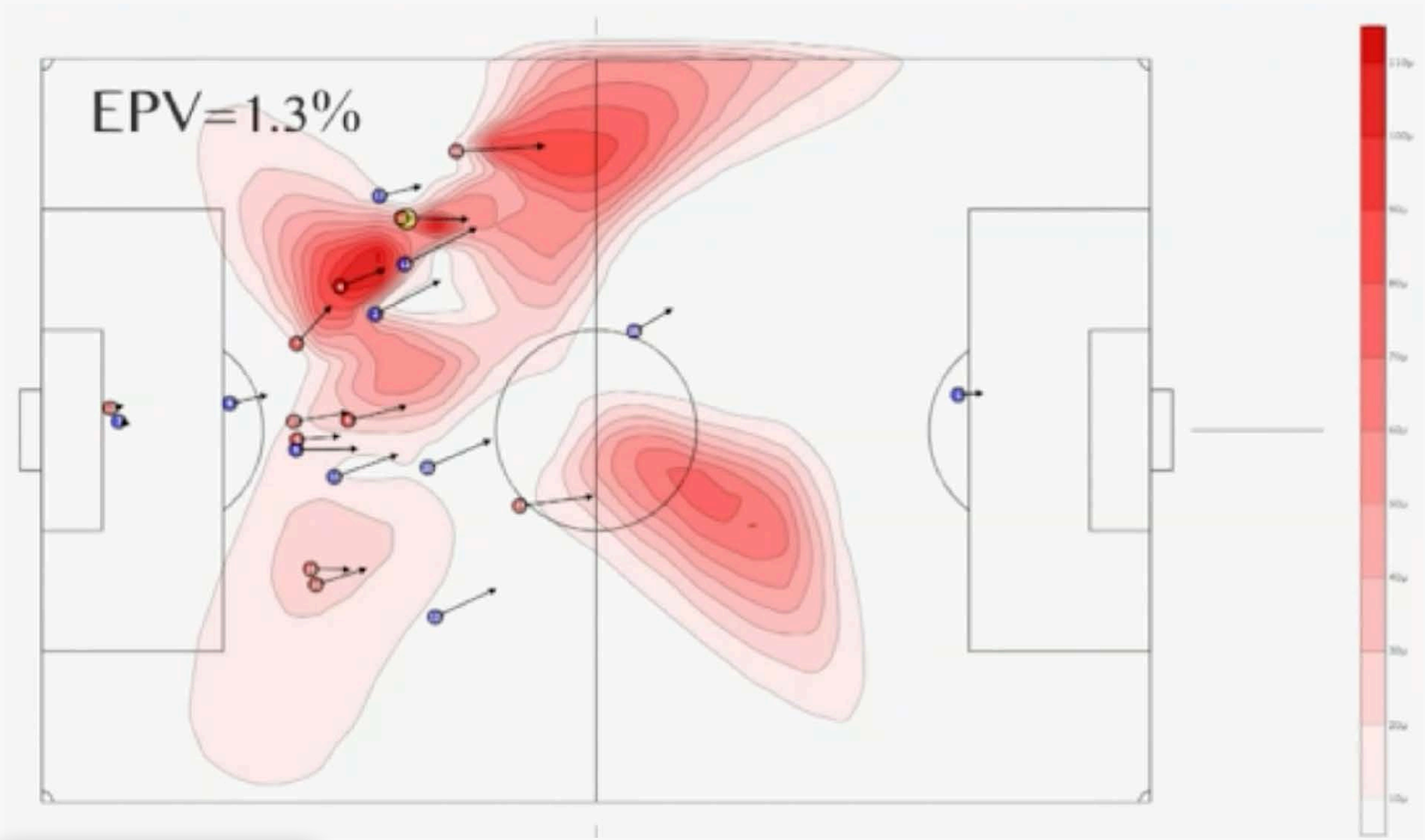


GPS

Sports Brackets



Football

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Carbon Dating

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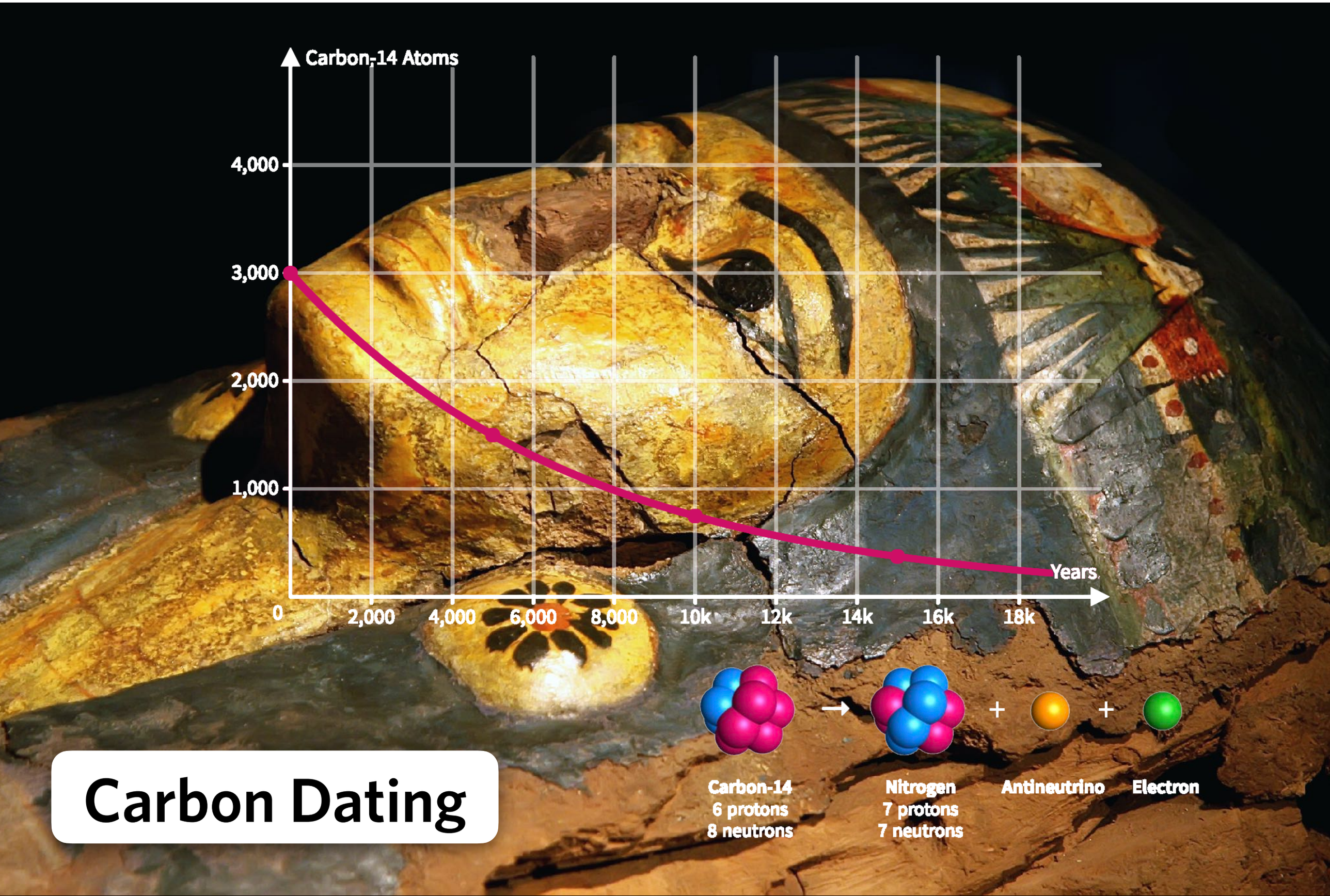

Carbon Dating

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Cicadas

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Public Key Cryptography

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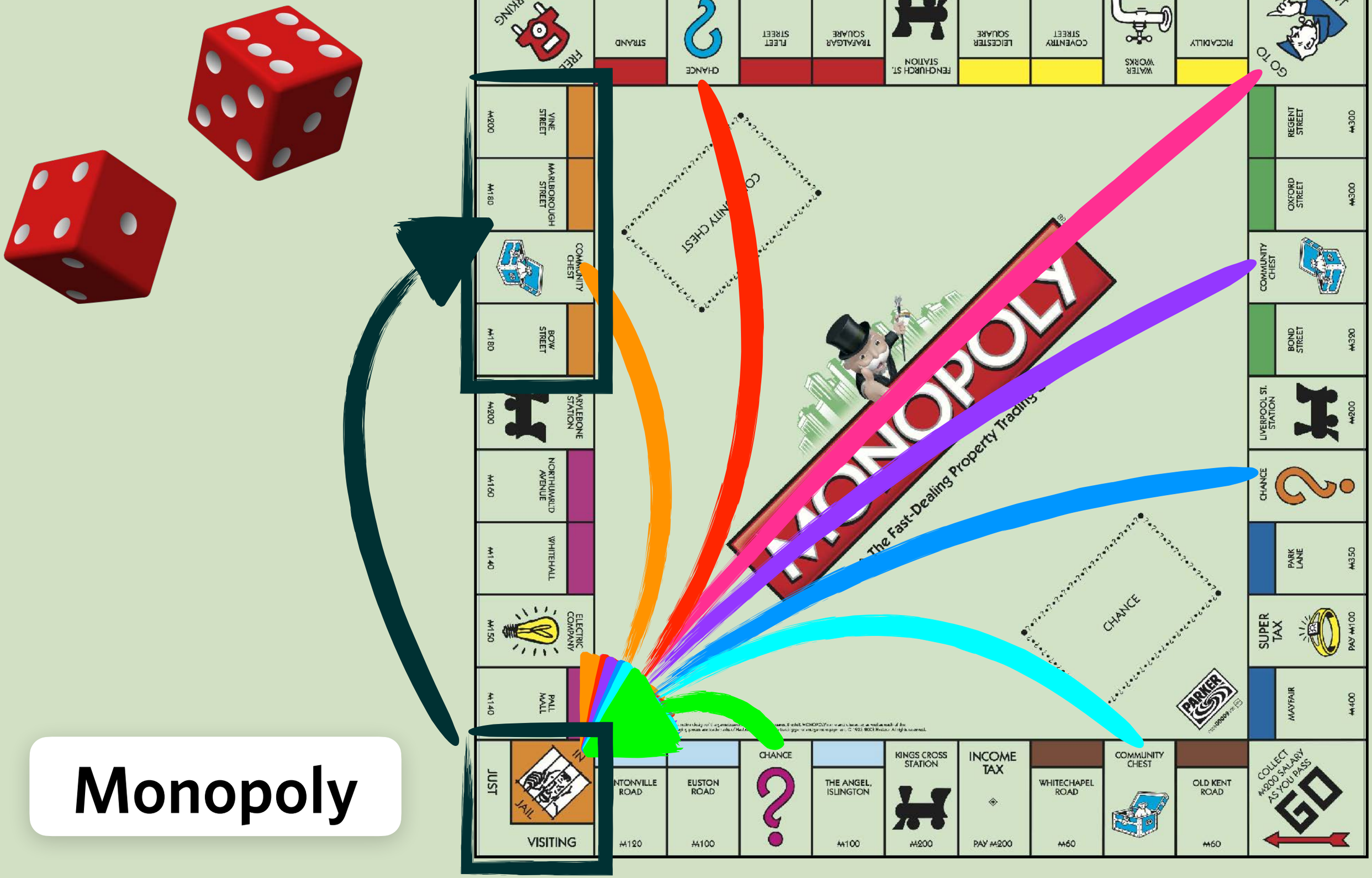
Roller Coasters

Position

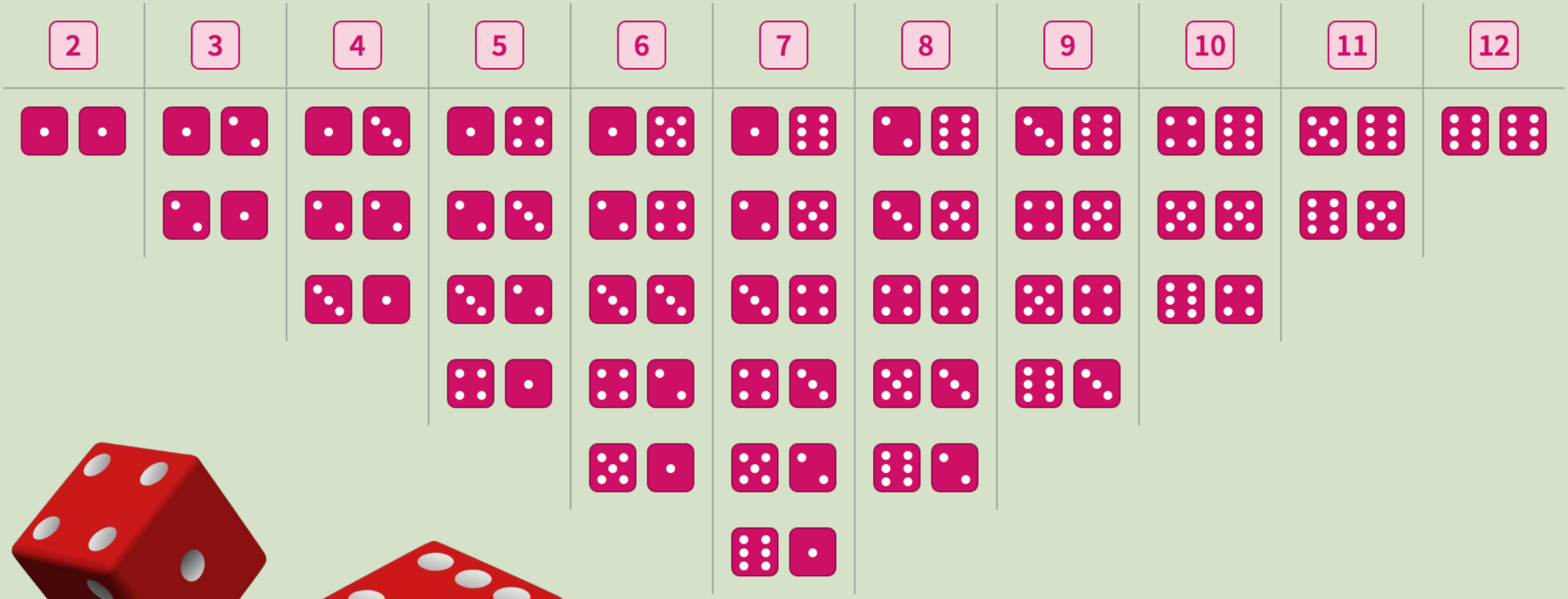
Velocity

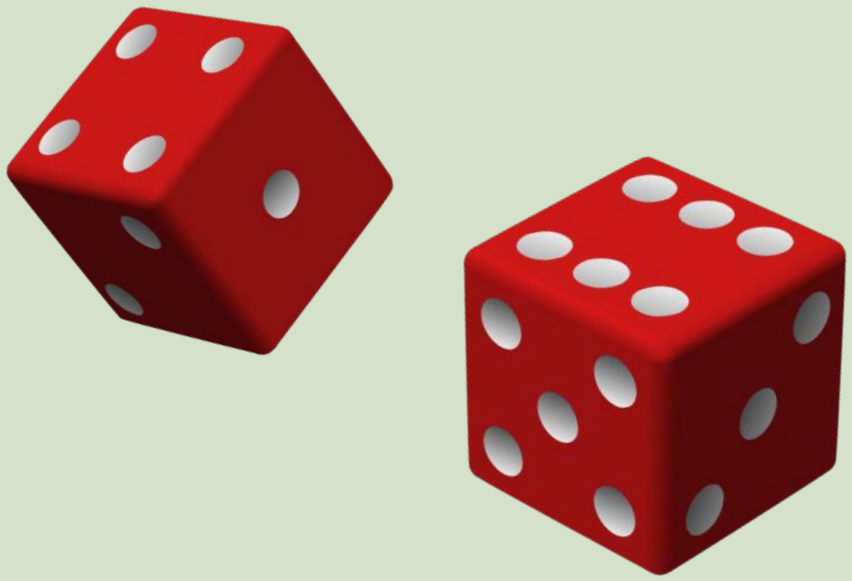
Acceleration

Jerk


GO TO JAIL
PICCADILLY
WATER WORKS
COVENTRY STREET
LEICESTER SQUARE
FENCHURCH ST. STATION
TRAFALGAR SQUARE
FLEET STREET
CHANCE
STRAND
FREE PARKING
REGENT STREET
OXFORD STREET
COMMUNITY CHEST
BOND STREET
LIVERPOOL ST. STATION
CHANCE
PARK LANE
SUPER TAX
MAYFAIR
COMMUNITY CHEST
VINE STREET
MARLBOROUGH STREET
COMMUNITY CHEST
BOW STREET
MARYLEBONE STATION
NORTHUMBERLAND AVENUE
WHITEHALL
ELECTRIC COMPANY
PALL MALL
JUST IN JAIL
VISITING
ENTONVILLE ROAD
EUSTON ROAD
CHANCE
THE ANGEL, ISLINGTON
KINGS CROSS STATION
INCOME TAX
WHITECHAPEL ROAD
COMMUNITY CHEST
OLD KENT ROAD
COLLECT ₥200 SALARY AS YOU PASS
GO
MONOPOLY
The Fast-Dealing Property Trading
CHANCE
PARKER

Monopoly



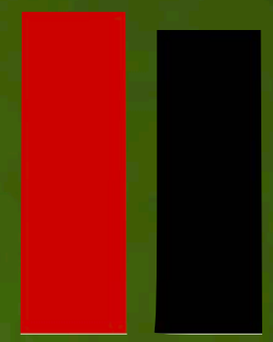


Monopoly


0
32
15
19
4
21
2
25
17
34
6
27
13
36
11
30
8
23
10
5
24
16
33
1
20
14
31
9
22
18
29
7
28
12
35
3
26

Roulette


0
32
15
19
4
21
2
25
17
34
6
27
13
36
11
30
8
23
10
5
24
16
33
1
20
14
31
9
22
18
29
7
28
12
35
3
26


Red
Black


RR
RB
BR
BB


RRR
RRB
BRR
RBR
BRB
BBR
RBB
BBB

Roulette

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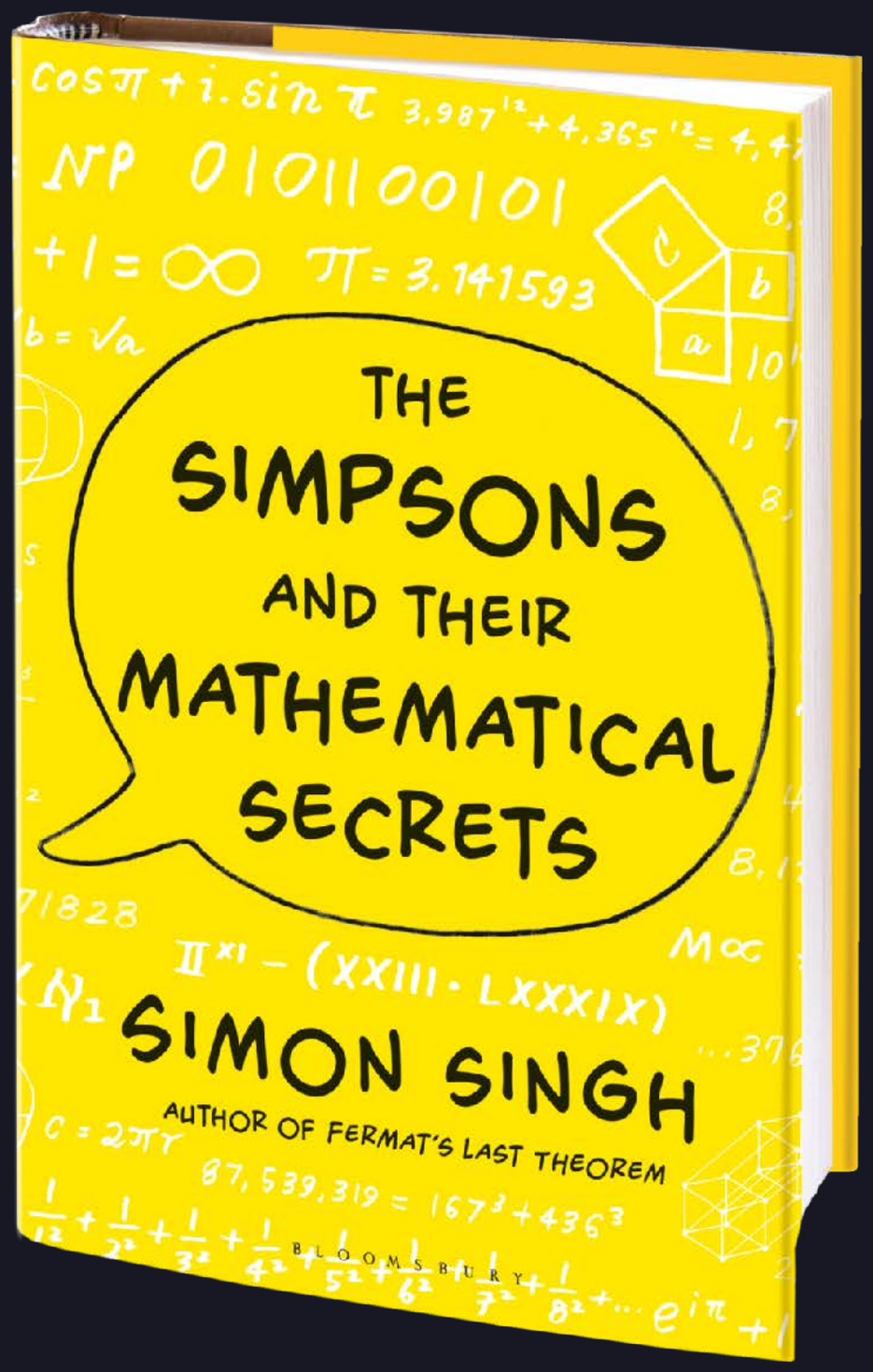
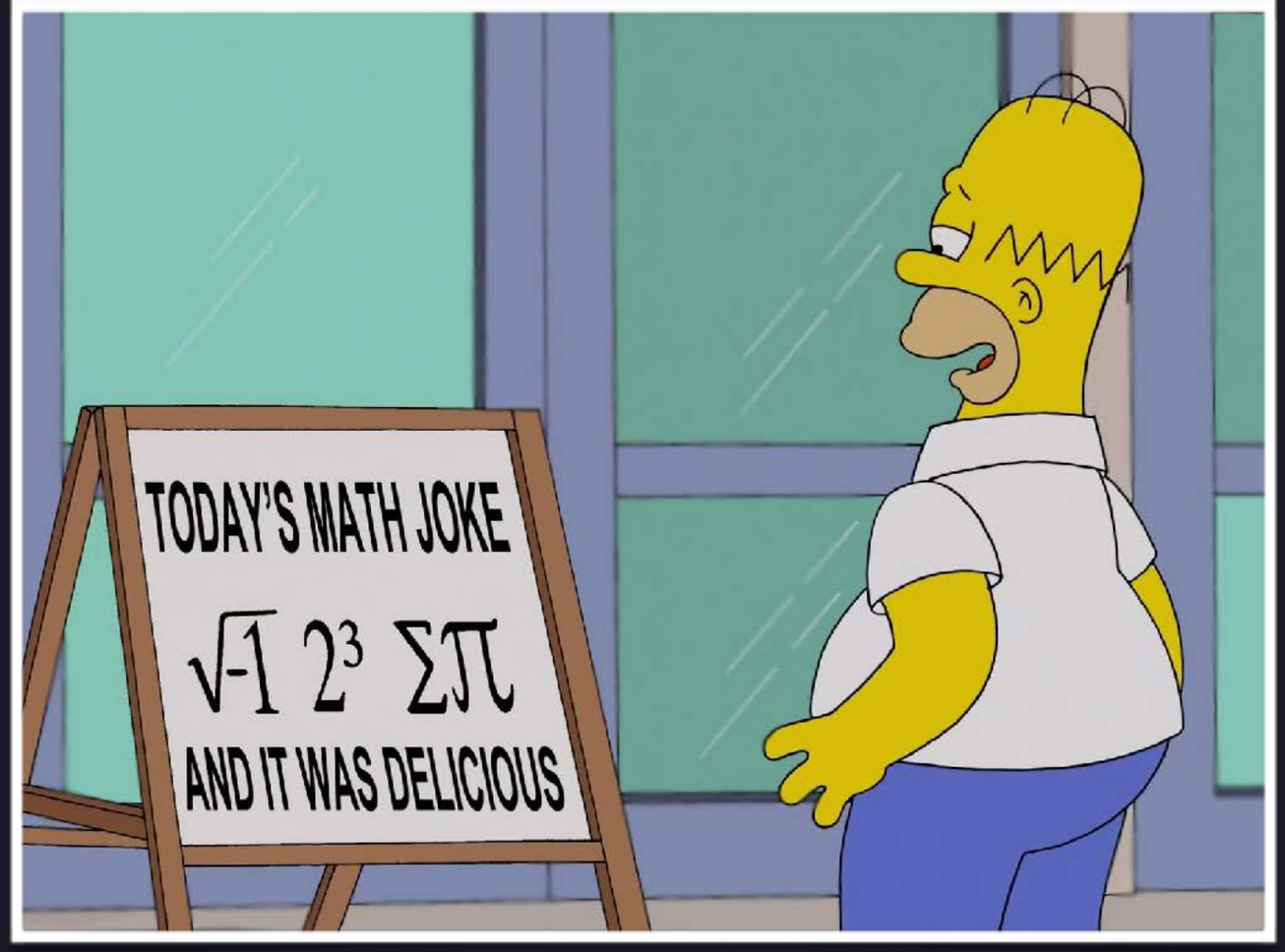
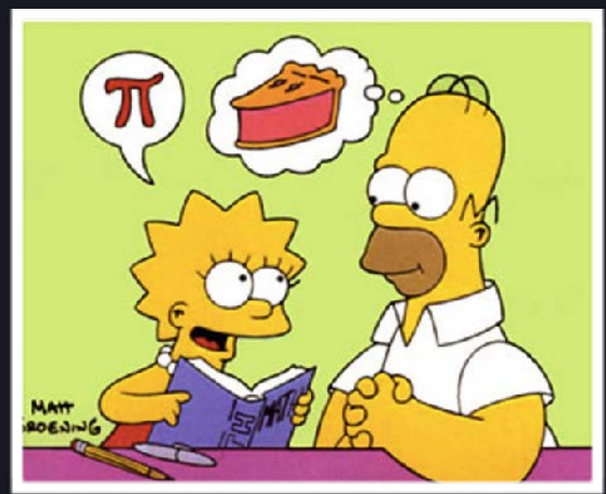
Lottery

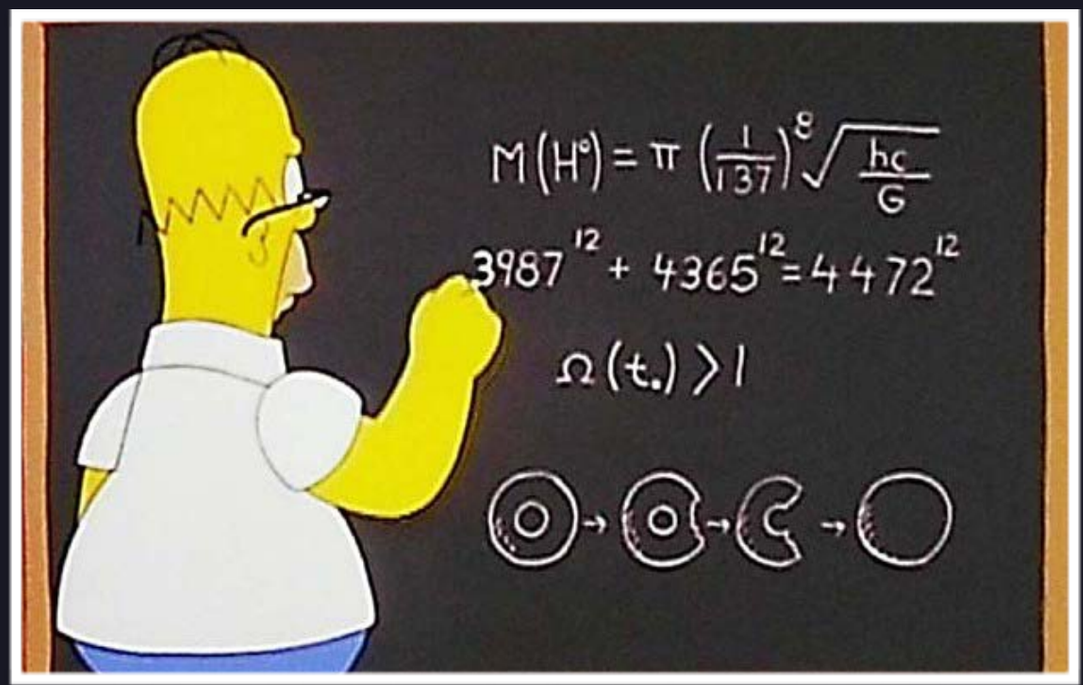

THE
SIMPSONS
AND THEIR
MATHEMATICAL
SECRETS
SIMON SINGH
AUTHOR OF FERMAT'S LAST THEOREM
BLOOMSBURY


TODAY'S MATH JOKE
√-1 2³ Σπ
AND IT WAS DELICIOUS


TONIGHT'S ATTENDANCE:
A) 8,191
B) 8,128
C) 8,208
D) No way to tell
JUMBO - VISION


π
MATT GROENING


DODECAHEDRON


M(H°) = π (1/137)⁸ √(hc/G)
3987¹² + 4365¹² = 4472¹²
Ω(t.) > 1

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mathigon.org/timeline

Timeline of Mathematics

Cavalieri
Desargues
Mersenne
Bernoulli
Stevin
Pascal
De Moivre
Galileo
Leibniz
Lambert
Viète
Fermat
Goldbach
Napier
Newton
Lagrange
Kepler
Bernoulli
Descartes
Wallis
Euler
Gauss
Fourier
Lagrange
Bernoulli
Riemann
Boole
Abe
Carroll
Lovelac
Cayley
Hilbert
Cantor
G
Poincaré
Erdős
Nash
Johnson
Mandelbrot
Lorenz
Wiles
Perelman
Conway
Turing
Ramar
Penrose
Mirzak

Enlightenment

Modern

1600 1700 1800 1900 2000

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Mathematics is filled with Stories!

Applications

Science and Nature

Games and Puzzles

History and Mathematicians

Fiction

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Stories are great for teaching!

Get students excited and motivated

Make the content more memorable

Show careers and people who use math

Encourage to keep studying math and STEM

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Creativity

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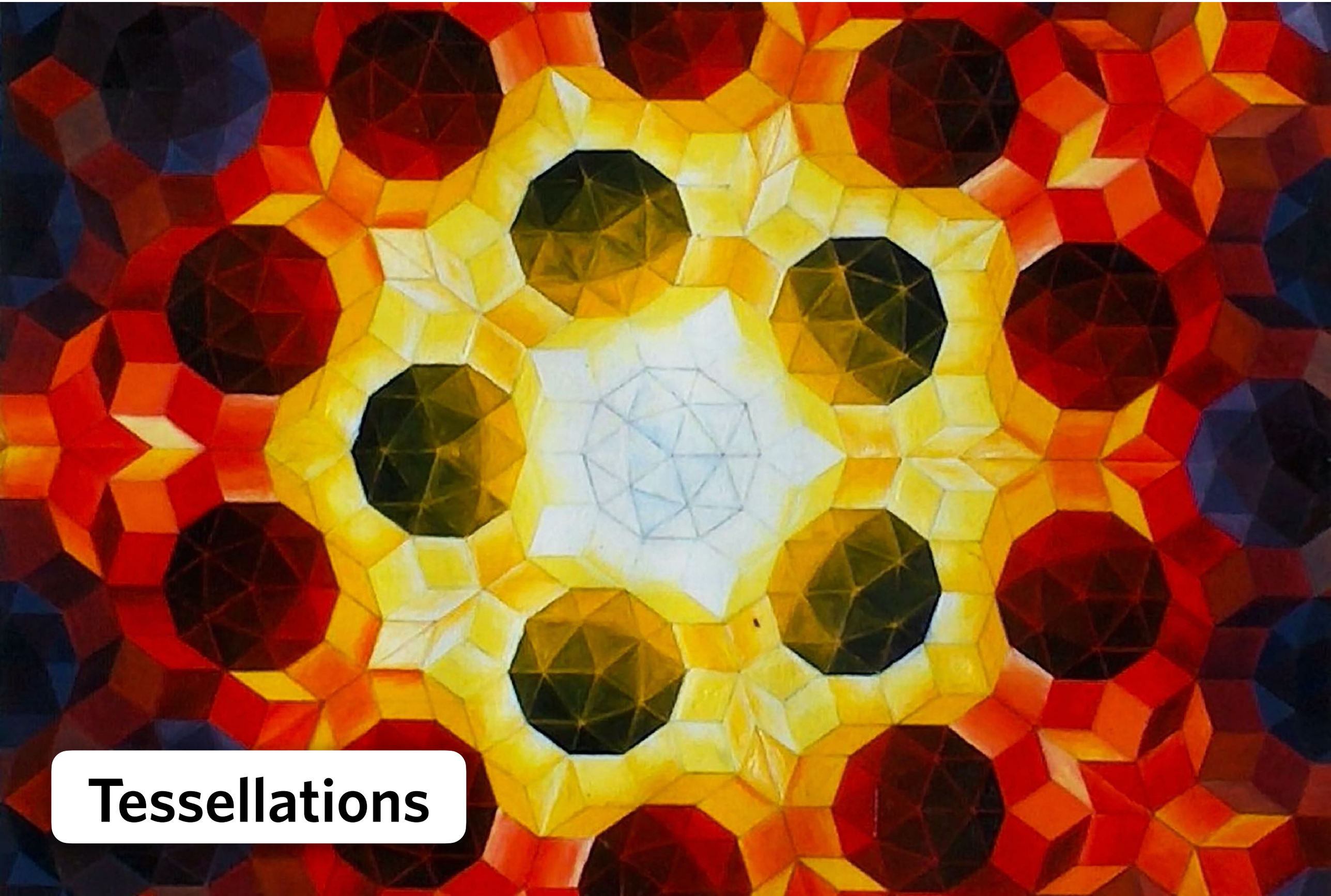

Tessellations

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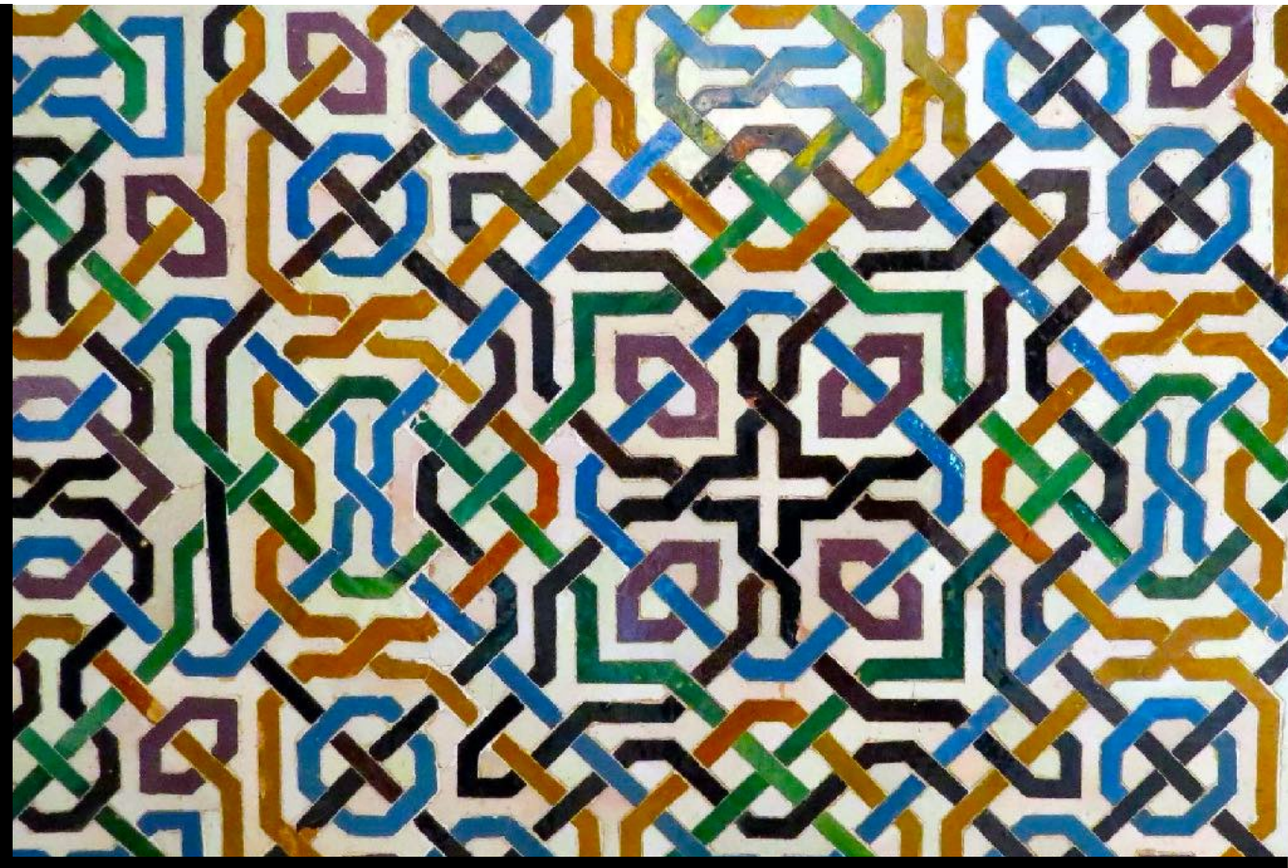
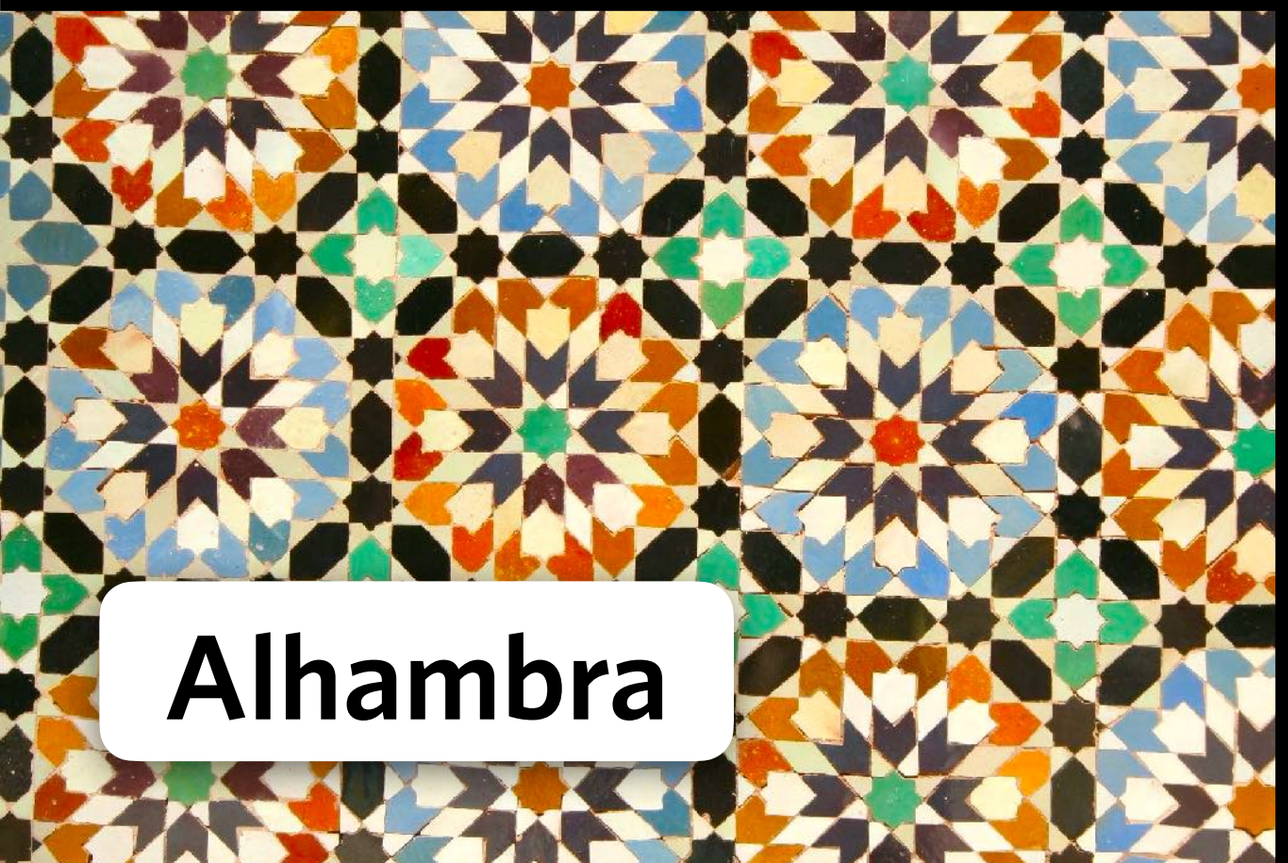
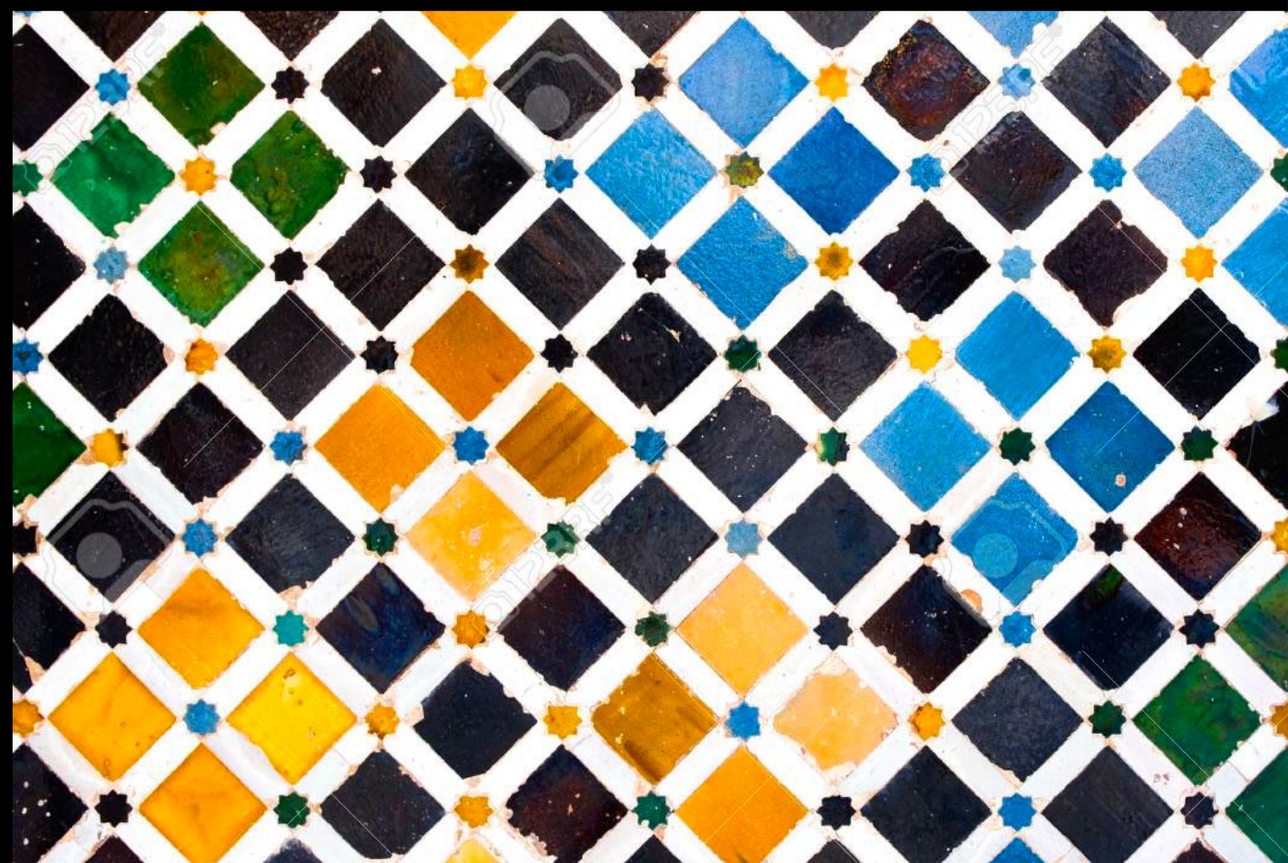
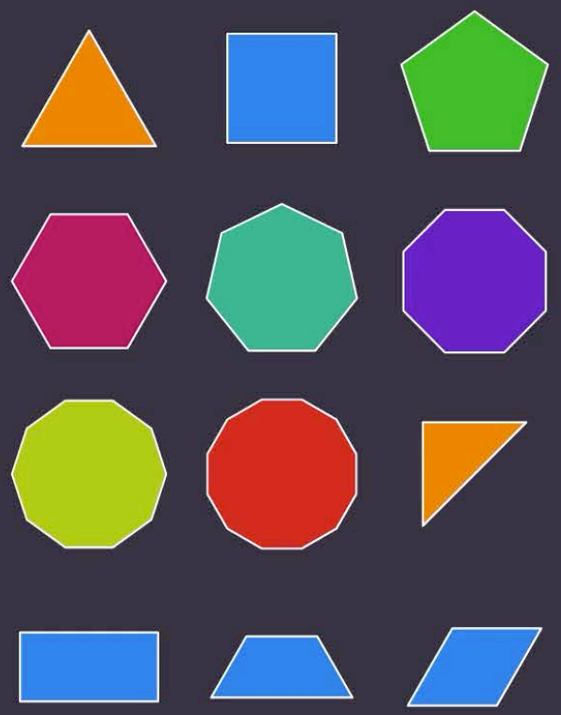




Alhambra

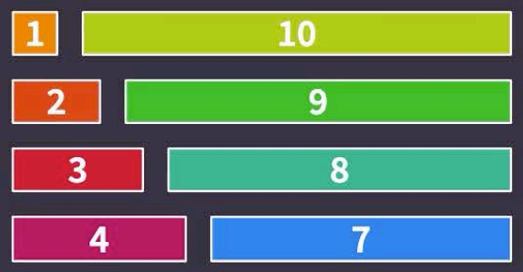


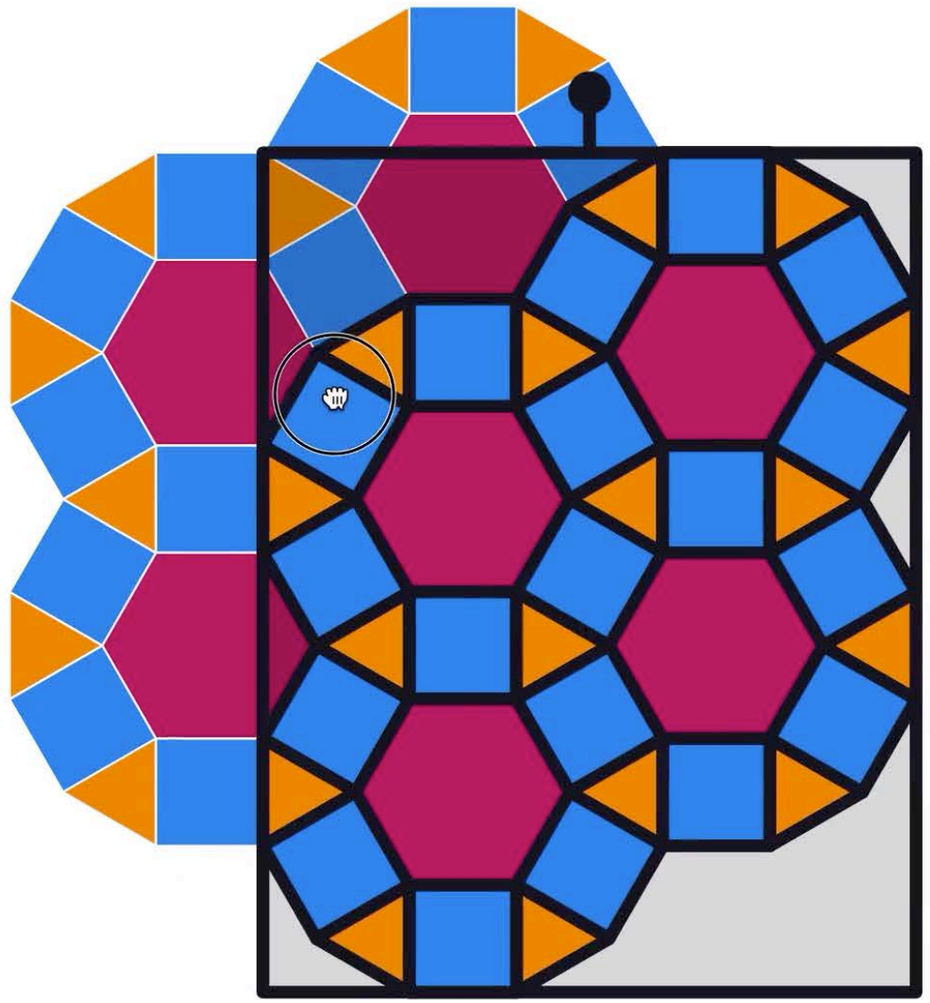
POLYGONS

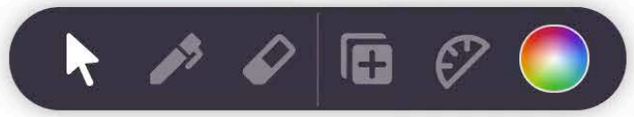


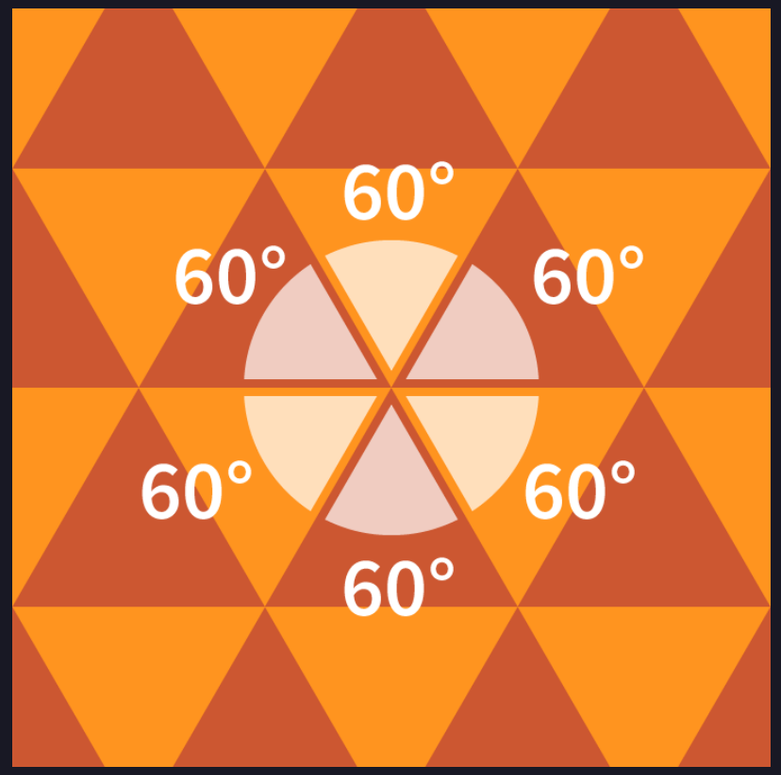
NUMBER TILES

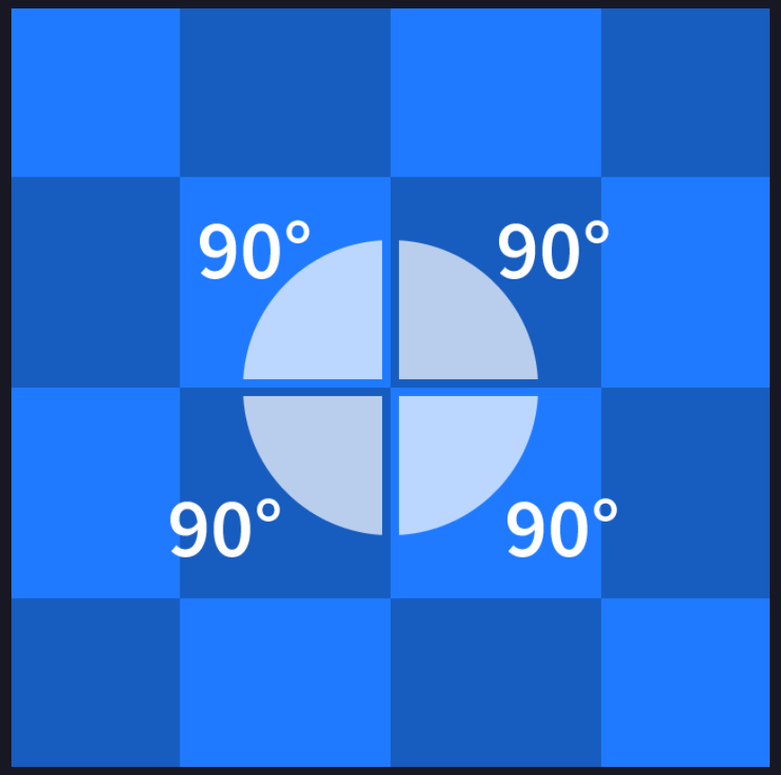
NUMBER BARS

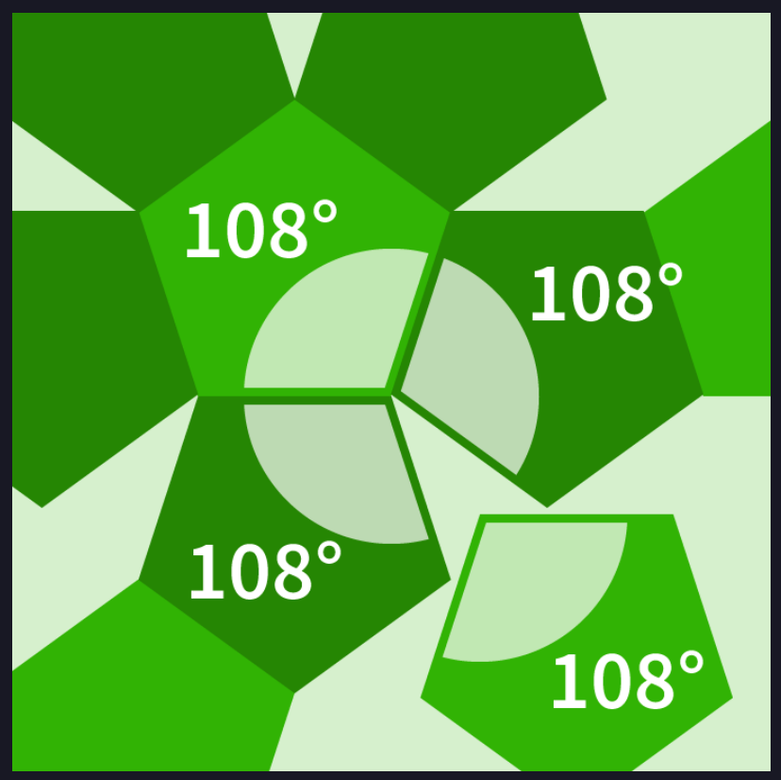


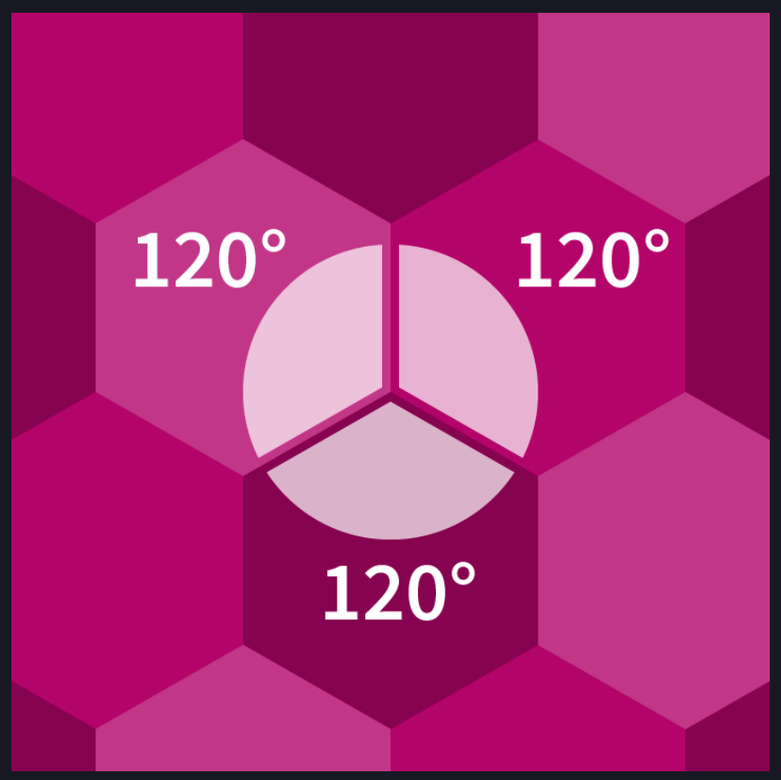





60°
60°
60°
60°
60°
60°


90°
90°
90°
90°


108°
108°
108°
108°


120°
120°
120°

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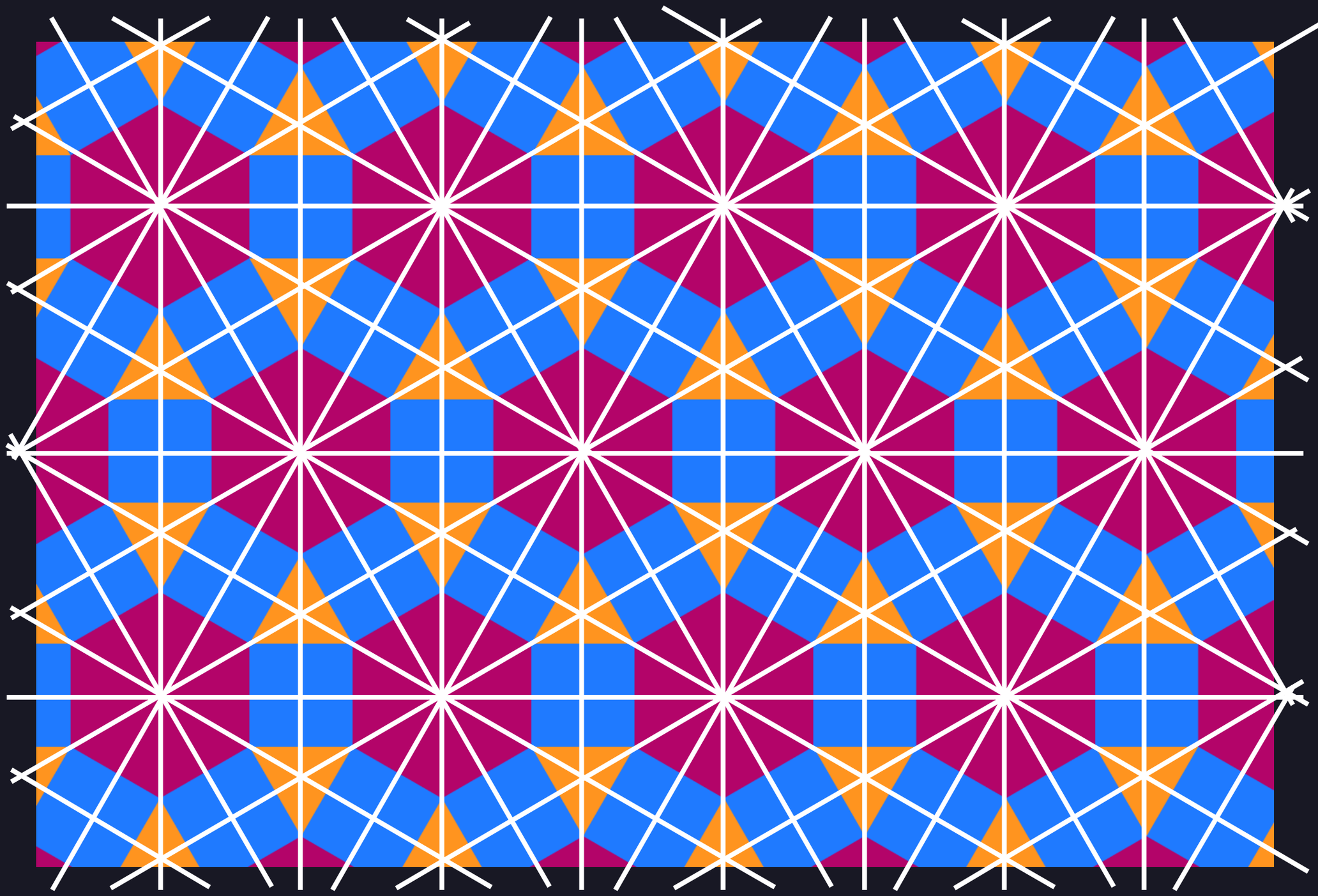

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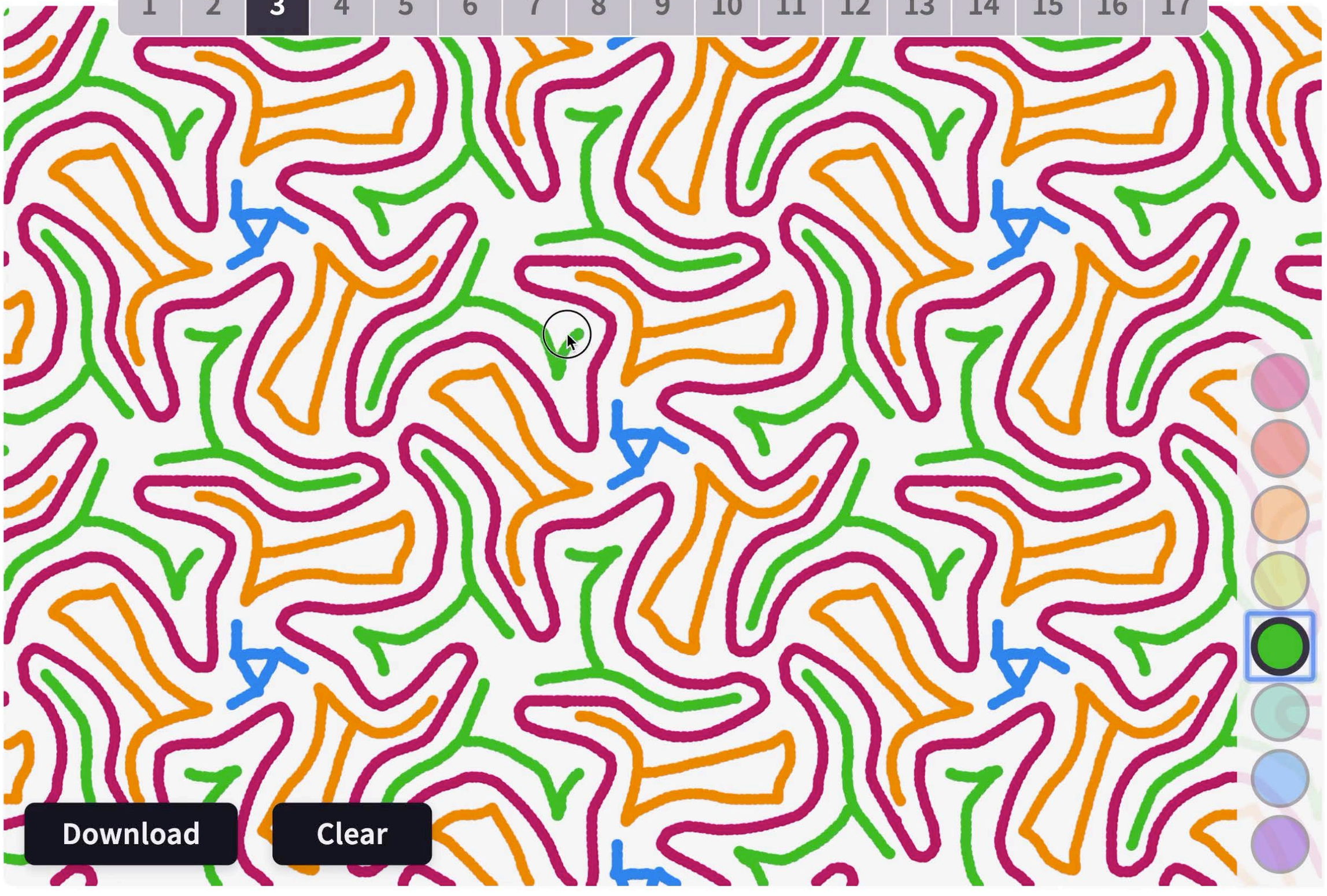
mathigon.org/go/wallpaper

17 Wallpaper Groups

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



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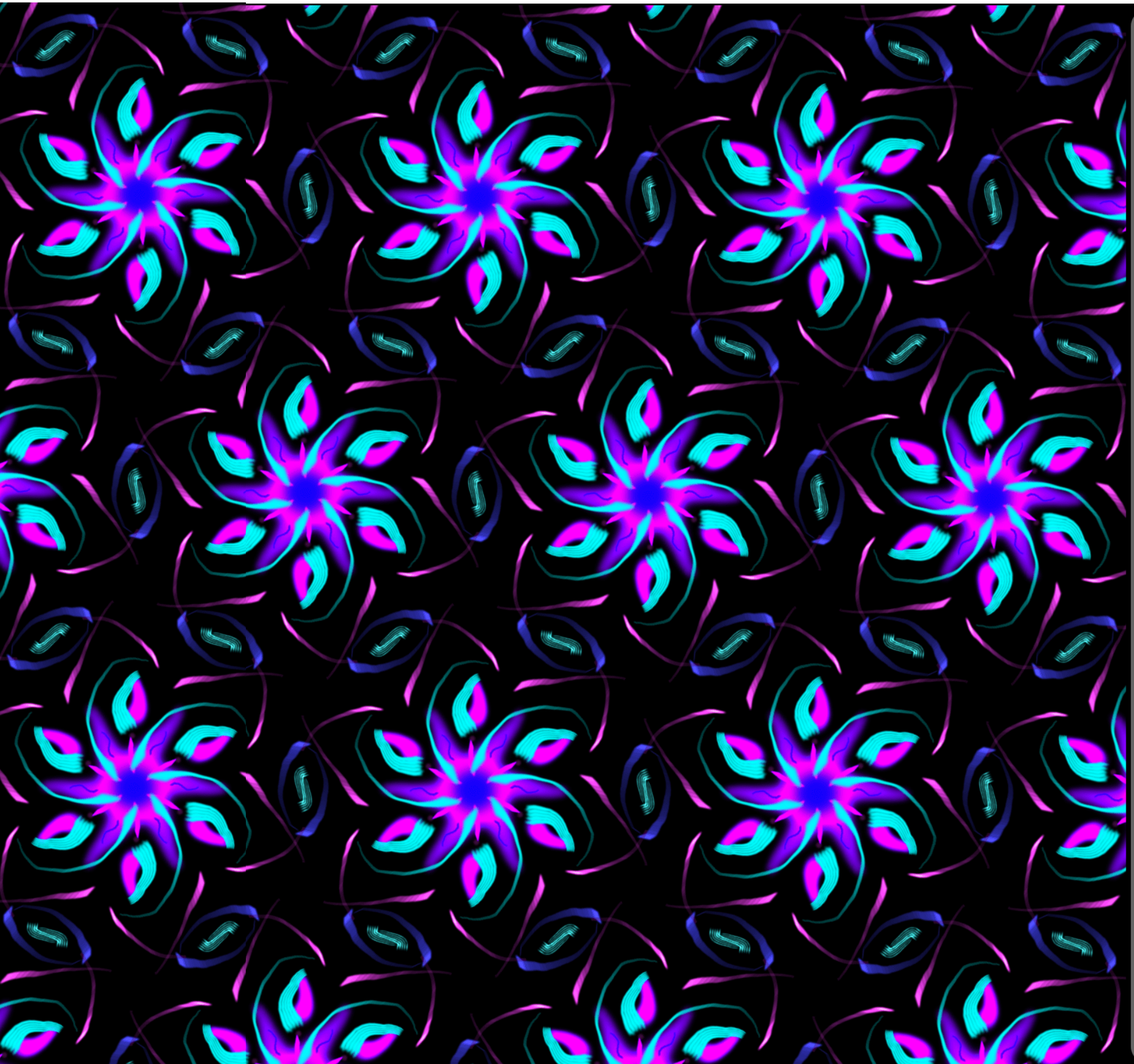
science-to-touch.com – $3.99



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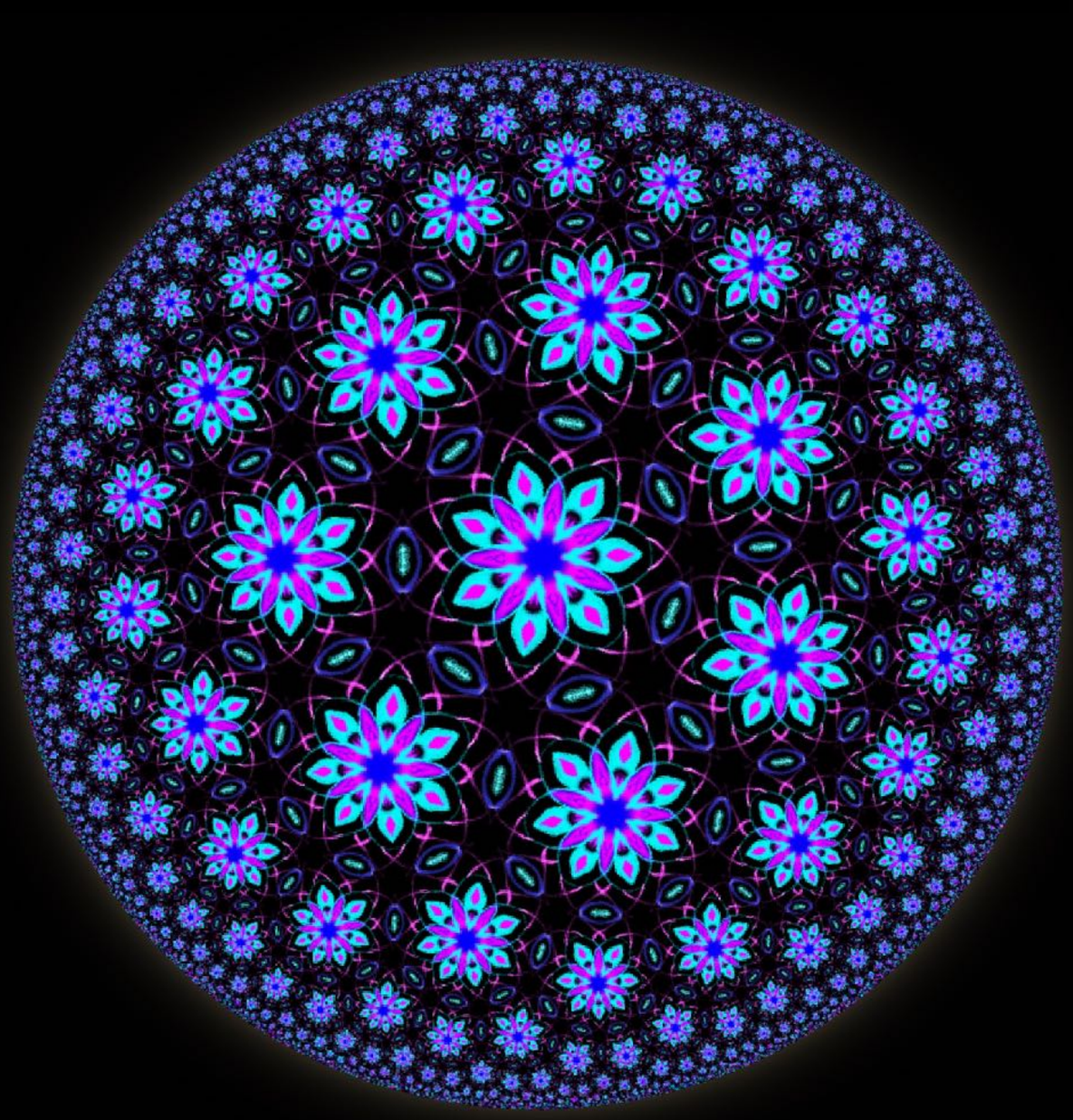
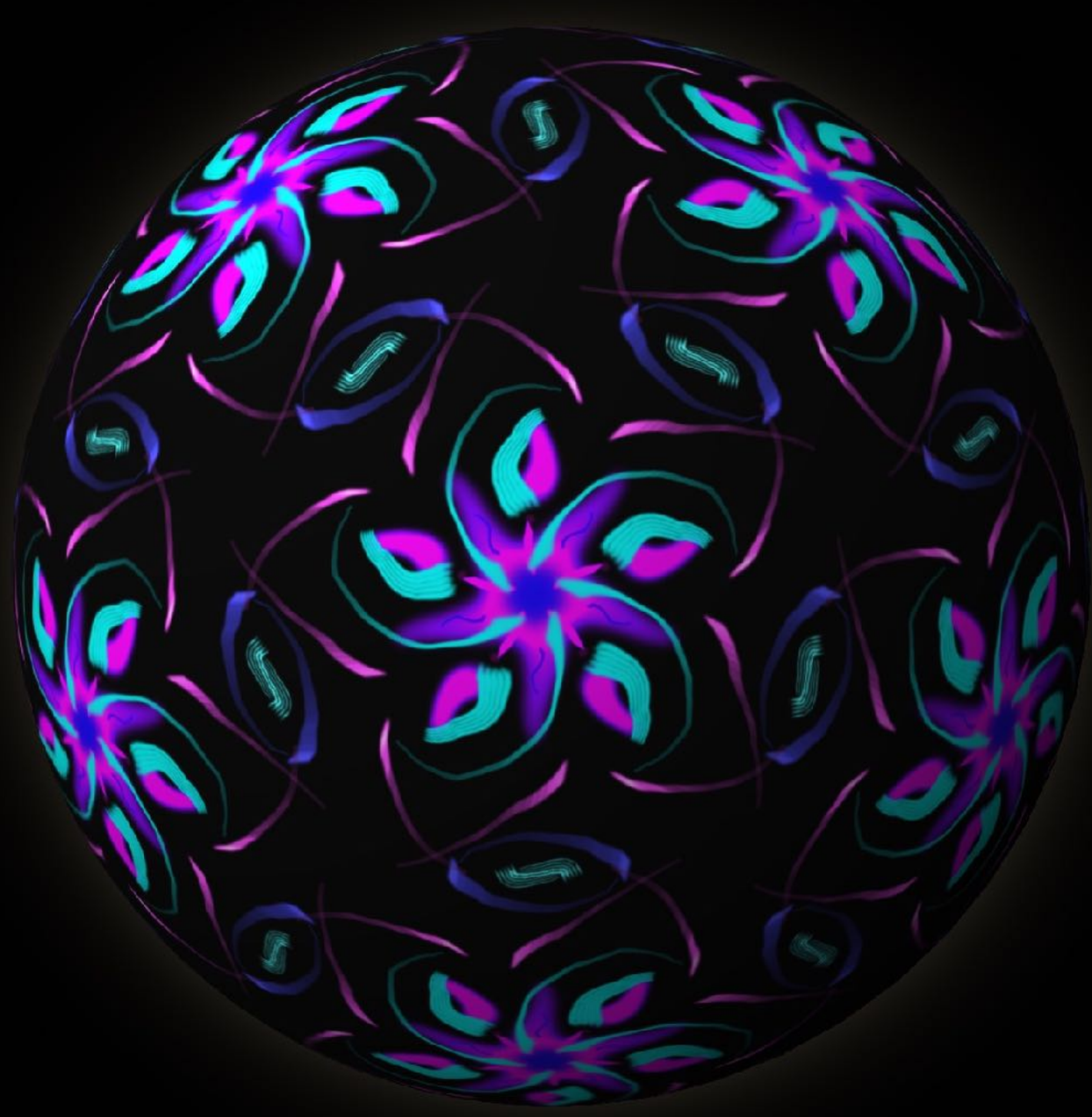
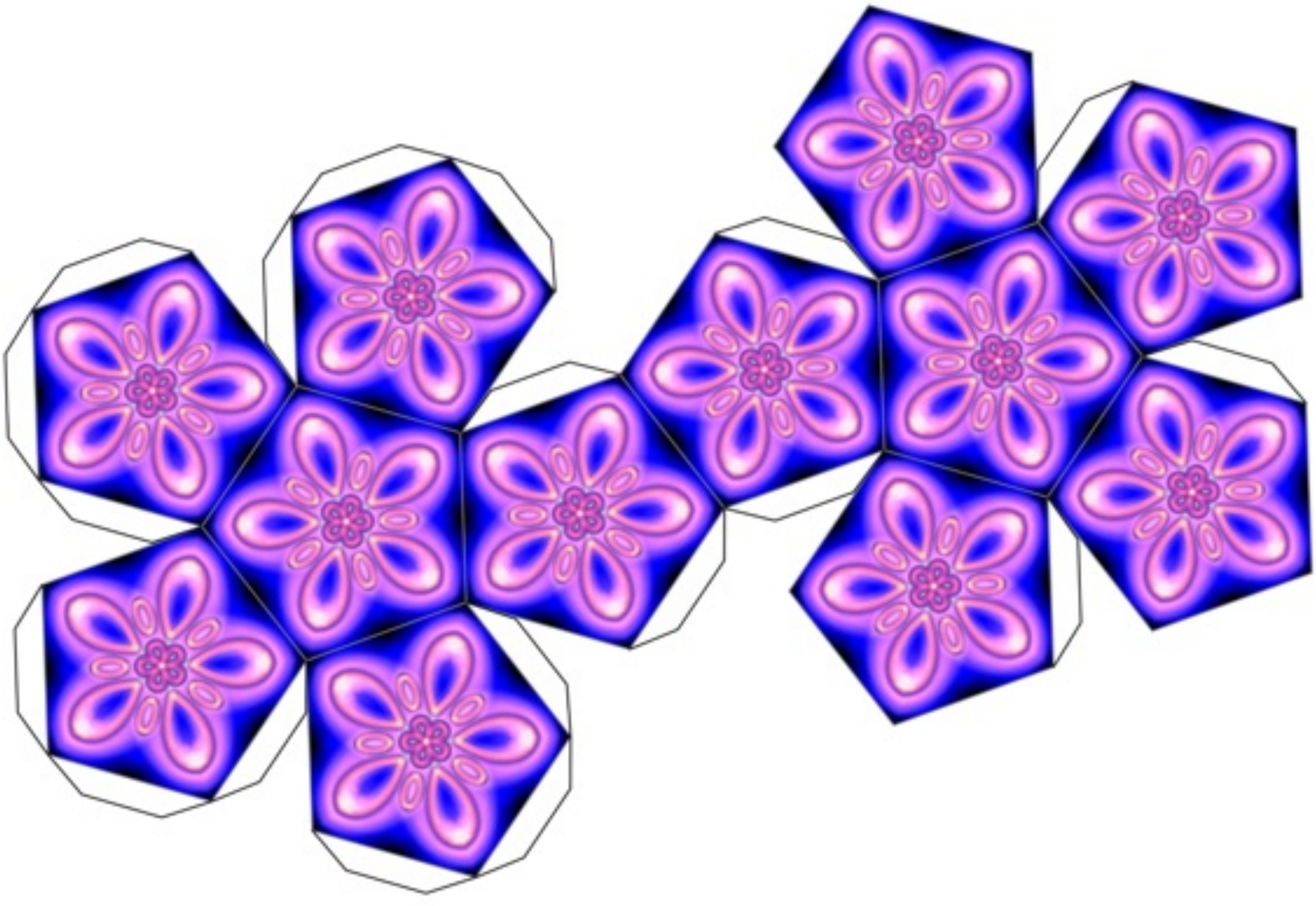
science-to-touch.com – $3.99







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science-to-touch.com – $3.99

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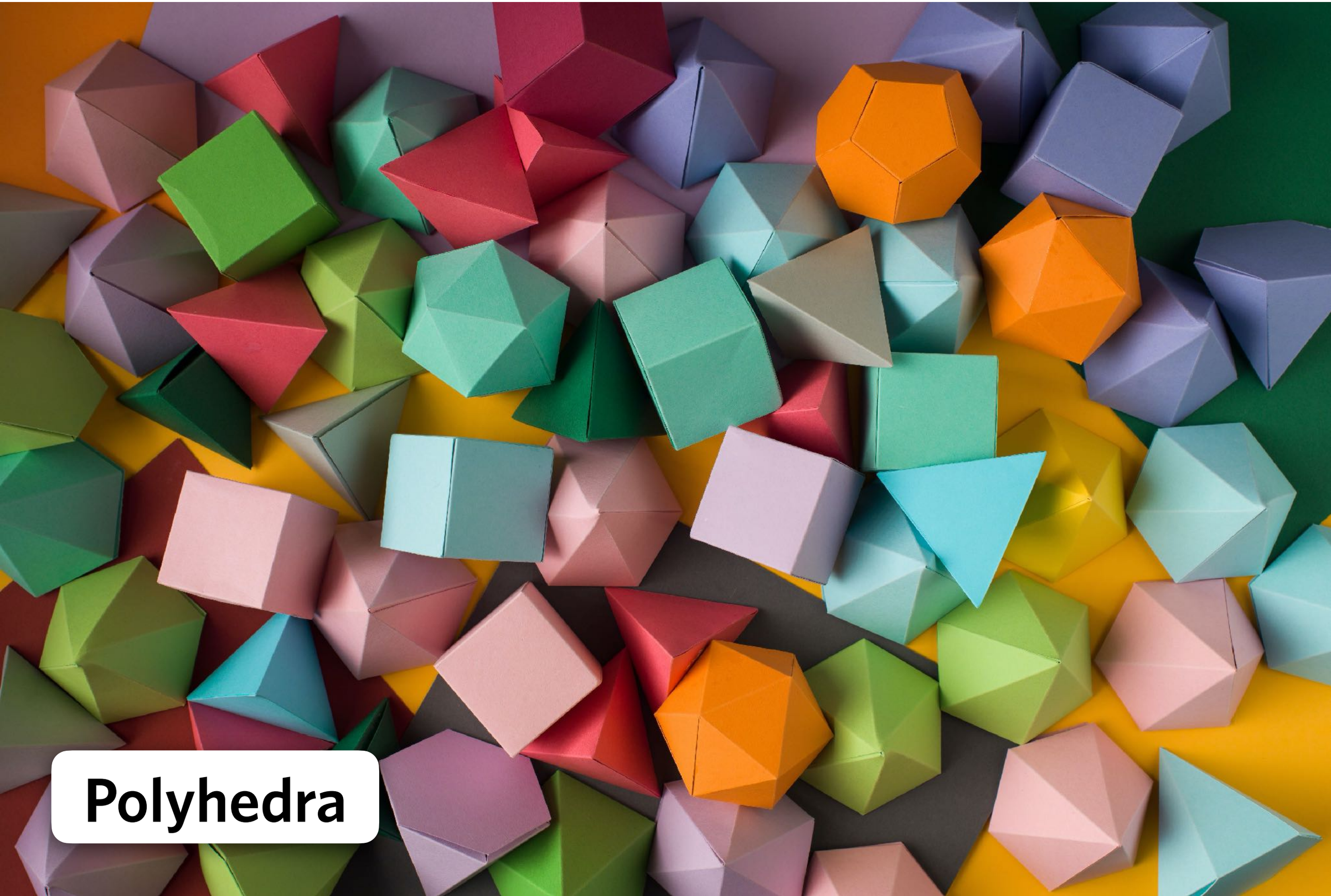
TEACHERS OF MATHEMATICS
CELEBRATING 100 YEARS



Polyhedra

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Volume
Surface Area
Nets/Cross Sections
Euler's Formula
5 Platonic Solids

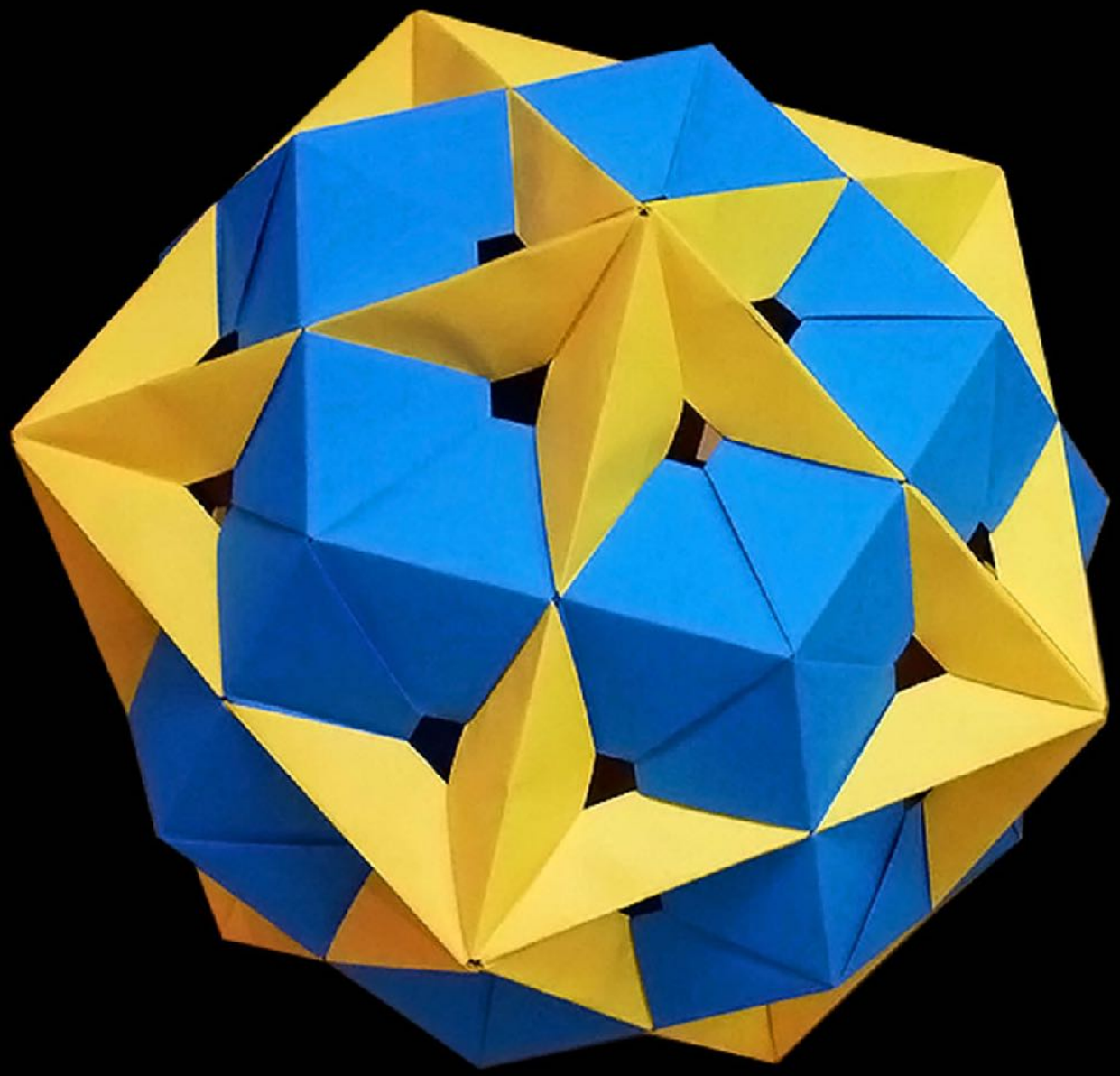

Photo by Dirk Eisner

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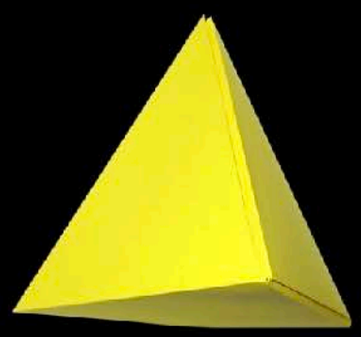
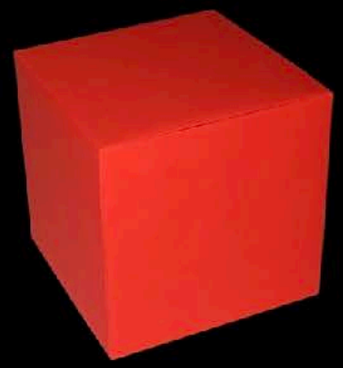
mathigon.org/origami



Tetrahedron

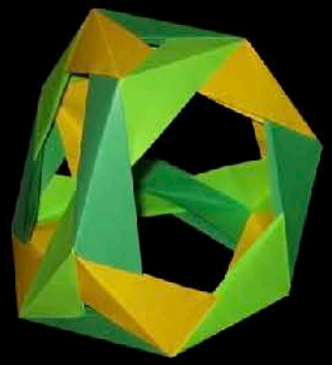


Cube

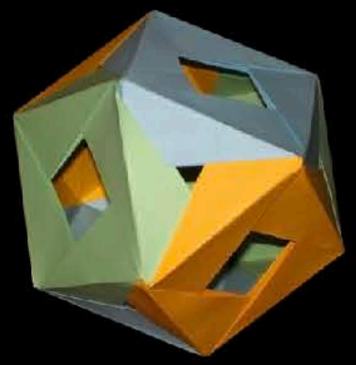
Octahedron

Dodecahedron

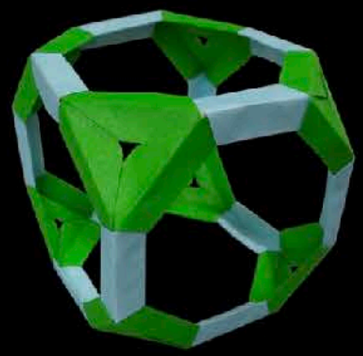
Icosahedron



Truncated Tetrahedron

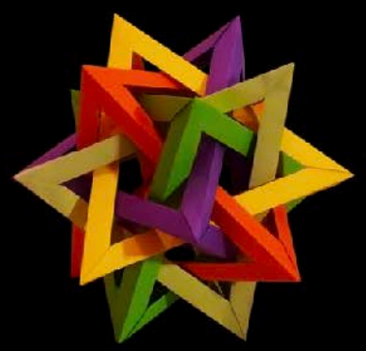


Cuboctahedron

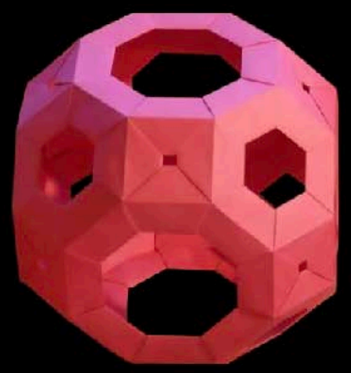


Truncated Hexahedron

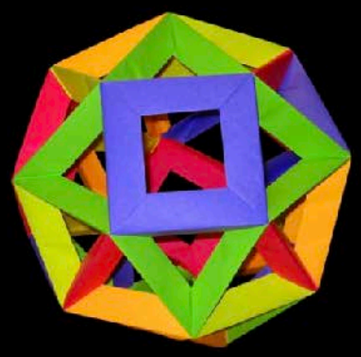
Truncated Octahedron



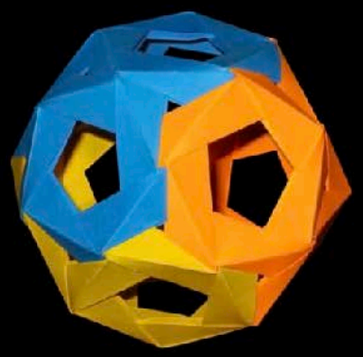
Intersecting Tetrahedra



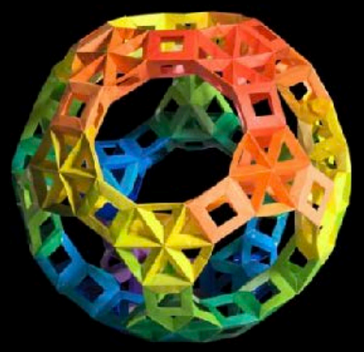
Truncated Cuboctahedron



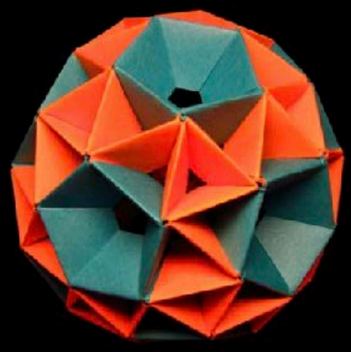
Snub Cube



Icosidodecahedron



Truncated Icosidodecahedron



Snub Dodecahedron

Photos by Dirk Eisner, Joel Lord, Andre Wiederkehr, Michal Kosmulski, noricum, ServeSmasher and fdecomite

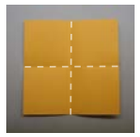
MATHIGON ORIGAMI

DRAGONS

★ ★ ★

more on mathigon.org/origami/

This model requires one quadratic sheet of paper.



Crease horizontally and vertically along centre.

Flip over and fold along both diagonals.

Put two opposite corners on top of each other, to create a smaller square.

Fold the bottom edges towards the centre.

Repeat previous step on opposite side.

Fold top triangle down.

Unfold the previous three steps.

Fold the bottom corner upwards.

Repeat previous step on opposite side.

Fold top two edges towards the centre.

Repeat previous step on opposite side.

'Close' the front two sides and repeat on the back.

Rotate by 180° and fold the first wing.

Fold top edges towards centre as shown.

Repeat previous two steps to create the second wing.

Fold up the neck of the dragon.

Fold neck twice in opposite directions for the head.

Fold the tail upwards.

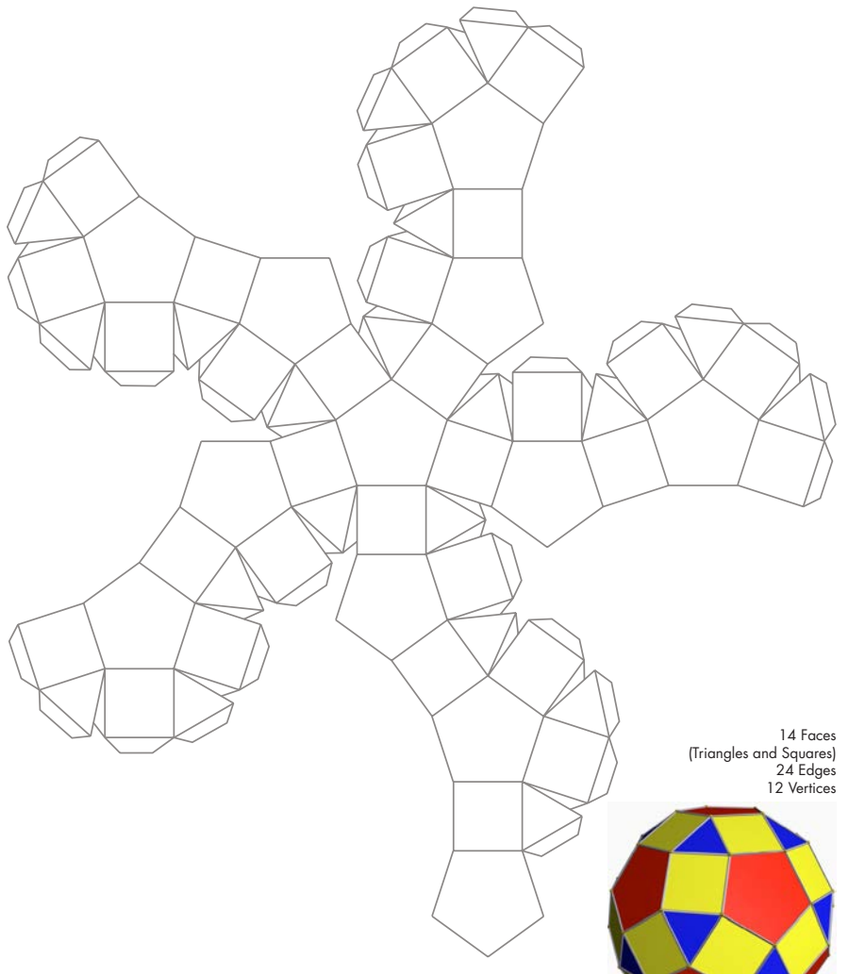
Add additional creases to both wings.

This is the final Origami Dragon.

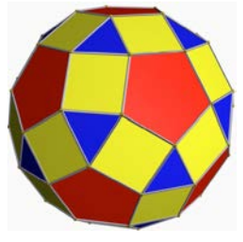
MATHIGON ORIGAMI

RHOMBICOSIDODECAHEDRON

more on mathigon.org/origami/



14 Faces
(Triangles and Squares)
24 Edges
12 Vertices



MATHIGON ORIGAMI

5 INTERLOCKING TETRAHEDRA

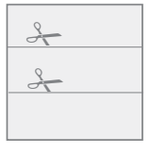
★ ★ ★ ★

more on mathigon.org/origami/

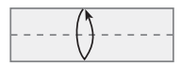
This model consists of the interlocking frames of five tetrahedra. It is one of the most difficult models on Mathigon.org, but also the most impressive.

Every tetrahedron is made out of six strips of paper with dimensions in the ratio 1:3. These can be created by cutting a square into three parts. We recommend that you use different colours for every tetrahedron, which means you need two squares in each of five colours.

Once you have created all 5 × 6 = 30 strips, they each need to be folded as follows:

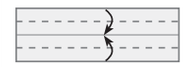


1



Fold along centre, then unfold.

2



Fold both edges towards centre, don't open.

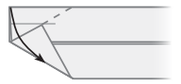
3

Fold both edges towards centre again, unfold.

4

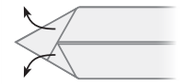
Fold bottom corner onto line in centre of top half.

5



Repeat for top corner.

6

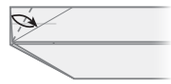


Unfold.

7

Fold bottom corner inwards.

8



Fold top corner as shown.

9

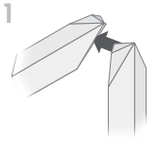
Rotate unit and repeat steps 3 to 8 at opposite end.

10

Fold entire unit along its centre.

Each of these 30 units will form the edge of one tetrahedron. At every vertex, three units link together:

11



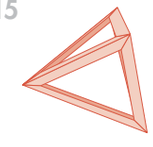
12

13

14

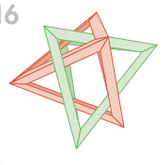
Now start connecting all units colour by colour, to form the five interlocking tetrahedra.

15

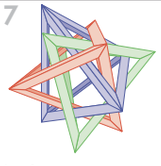


Connect all 6 units in any one colour to make the first tetrahedron.

16



17



For the second and third tetrahedra, first create one corner ('tripod') and interlink it with the existing shape. Then lock it in place using the remaining three edges of that colour.

18

Add the fourth and fifth Tetrahedra in a similar way.

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Intersecting Tetrahedra

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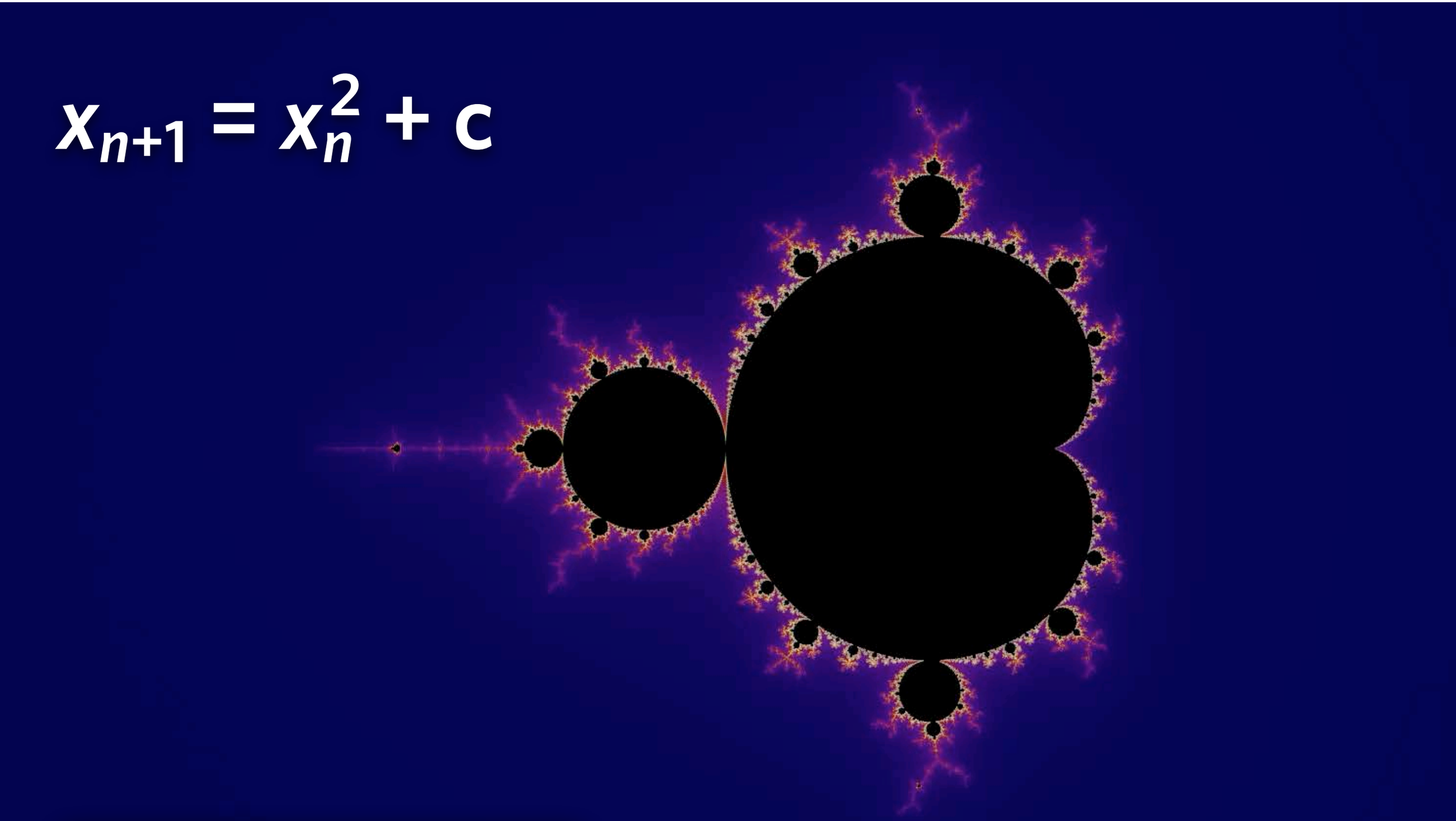
mathigon.org/go/mandelbrot

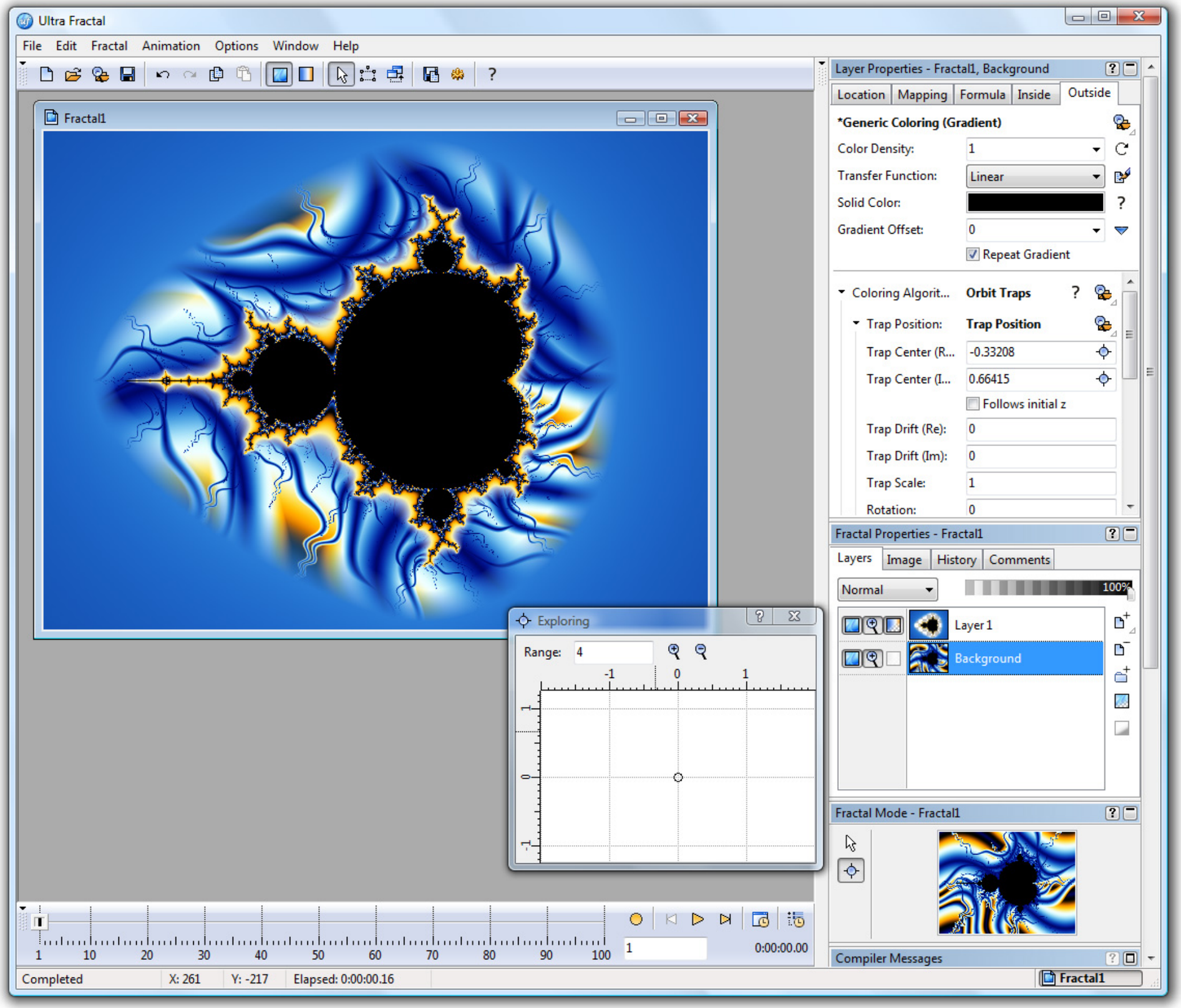
$$x_{n+1} = x_n^2 + c$$

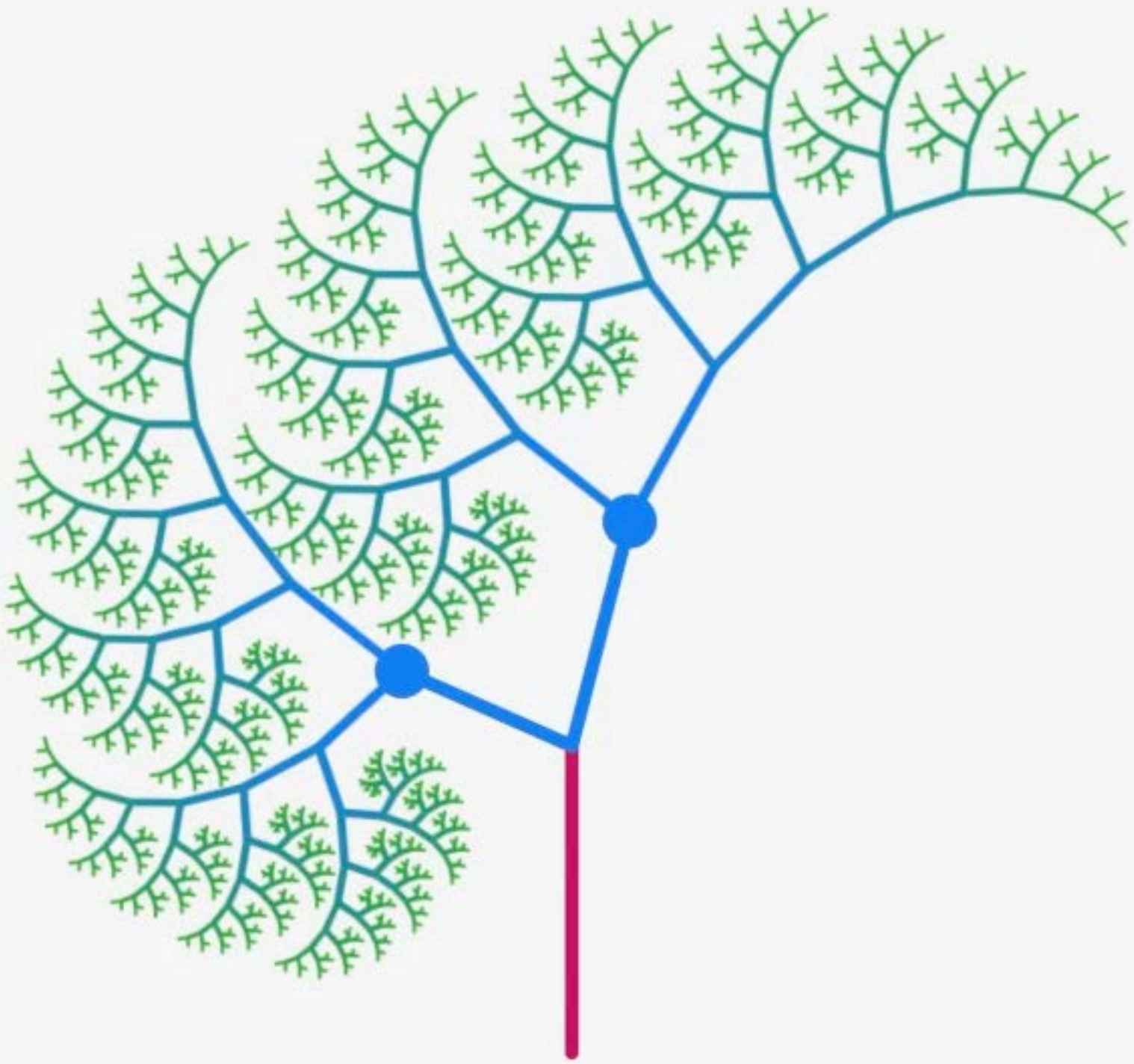


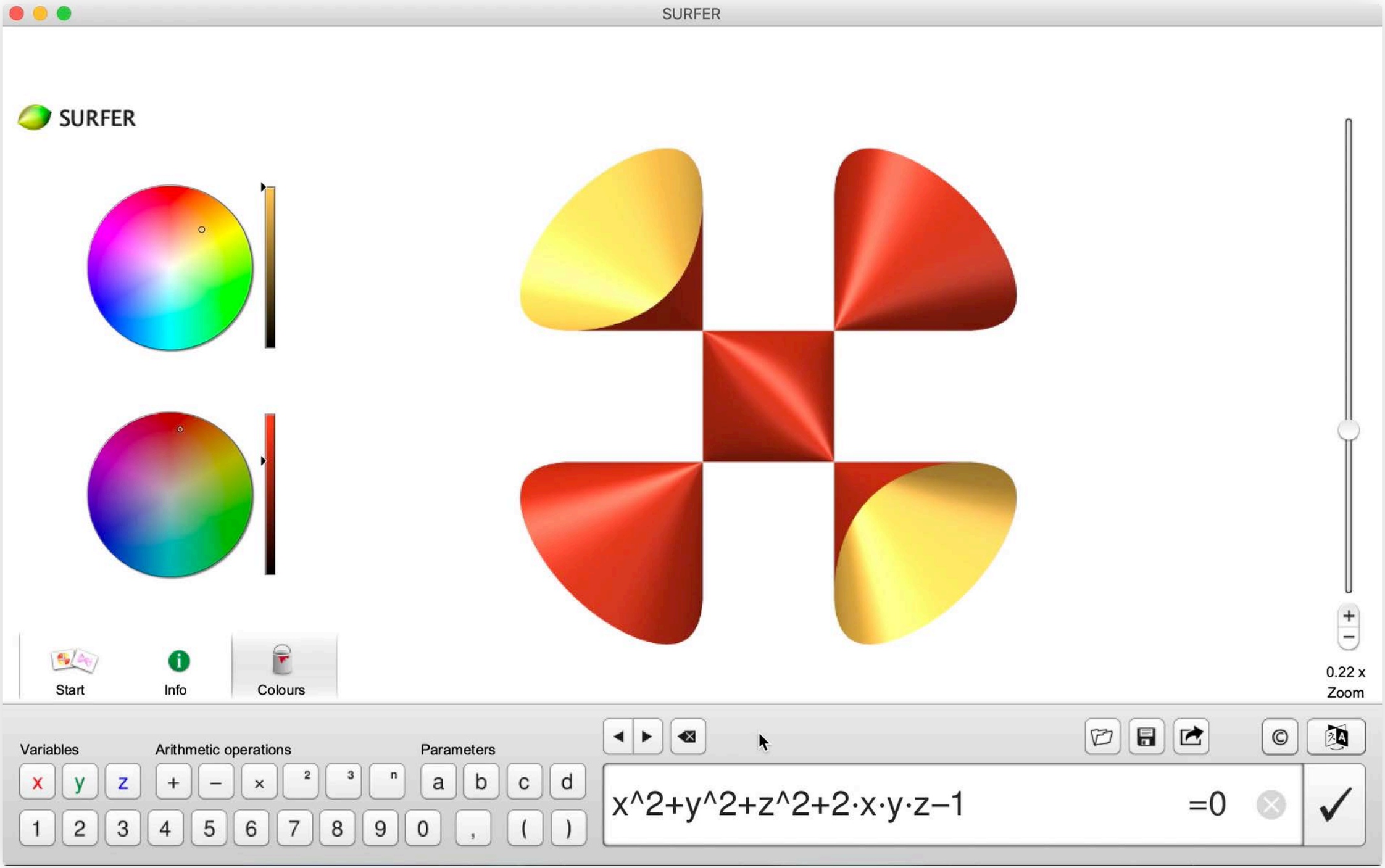
Mandelbrot Set

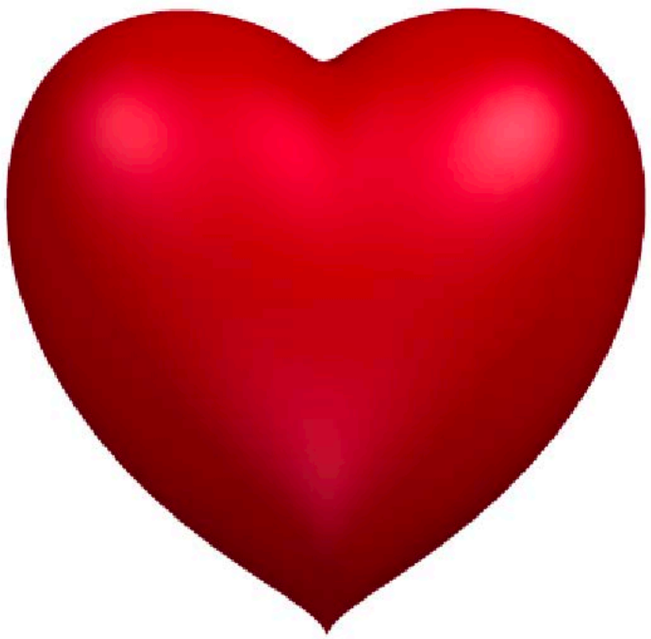
```
MandelComp = Compile[
    {{c, _Complex}},
    Module[{num = 1},
    FixedPoint[(num++;#^2 + c)&, 0, 8191, SameTest->(Re[#]^2 + Im[#]^2>=4&)];
    num],
    CompilationTarget->"C",
    RuntimeAttributes->{Listable},
    Parallelization->True
];
```

```
Mandelbrot[x_, y_, m_]:=ArrayPlot[
    MandelComp[Table[a + I b,
        {b, y - 2.7 * 2^-m, y + 2.7 * 2^-m, 0.005 * 2^-m},
        {a, x - 4.8 * 2^-m, x + 4.8 * 2^-m, 0.005 * 2^-m}(*0.002*)
    ]] / 8192,
    ColorRules->{1->Black},
    ColorFunction->MandelColor ,
    ColorFunctionScaling->False,
    Frame->False,
    PixelConstrained->1
];
```

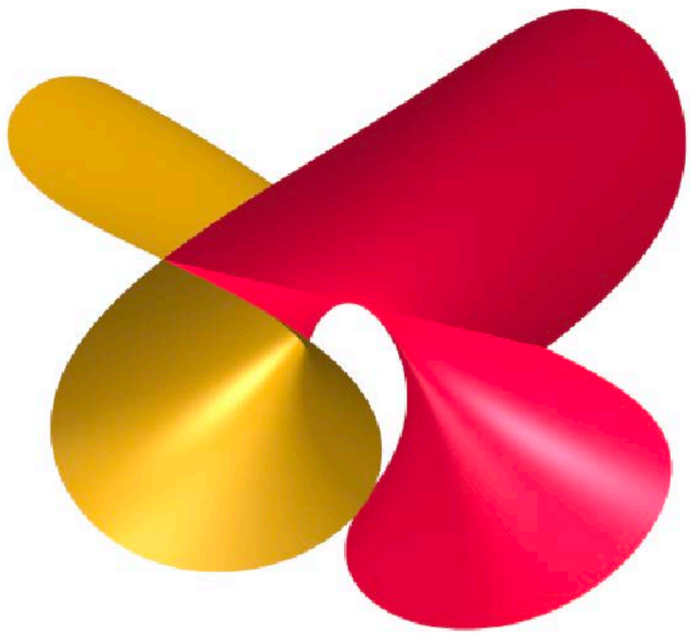

Ultra Fractal
File Edit Fractal Animation Options Window Help
Fractal1
Exploring
Range: 4
-1 0 1
Layer Properties - Fractal1, Background
Location Mapping Formula Inside Outside
*Generic Coloring (Gradient)
Color Density: 1
Transfer Function: Linear
Solid Color:
Gradient Offset: 0
Repeat Gradient
Coloring Algorit... Orbit Traps
Trap Position: Trap Position
Trap Center (R... -0.33208
Trap Center (I... 0.66415
Follows initial z
Trap Drift (Re): 0
Trap Drift (Im): 0
Trap Scale: 1
Rotation: 0
Fractal Properties - Fractal1
Layers Image History Comments
Normal 100%
Layer 1
Background
Fractal Mode - Fractal1
Compiler Messages
1 10 20 30 40 50 60 70 80 90 100
0:00:00.00
Completed X: 261 Y: -217 Elapsed: 0:00:00.16
Fractal1



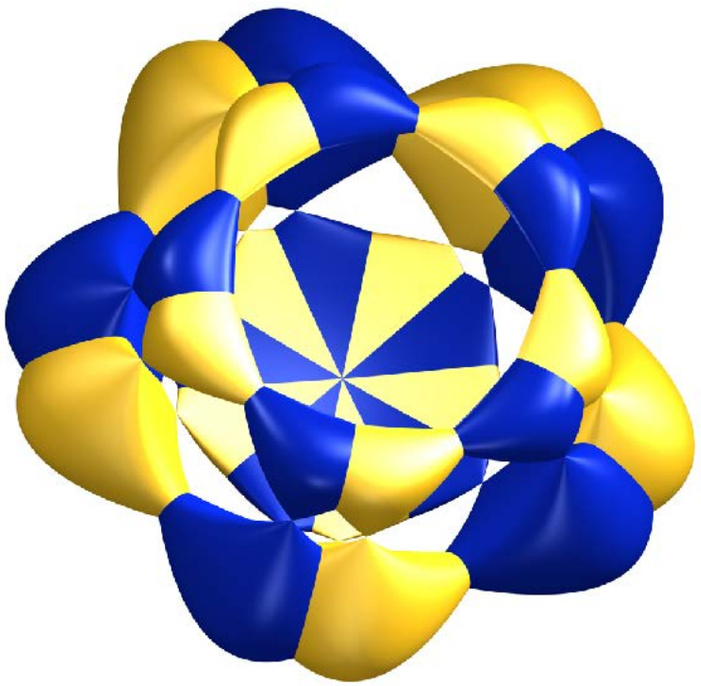

SURFER
SURFER
Start
Info
Colours
0.22 x
Zoom
Variables
Arithmetic operations
Parameters
x y z
+ − × ² ³ ⁿ
a b c d
1 2 3 4 5 6 7 8 9 0 , ( )
x^2+y^2+z^2+2·x·y·z−1 =0

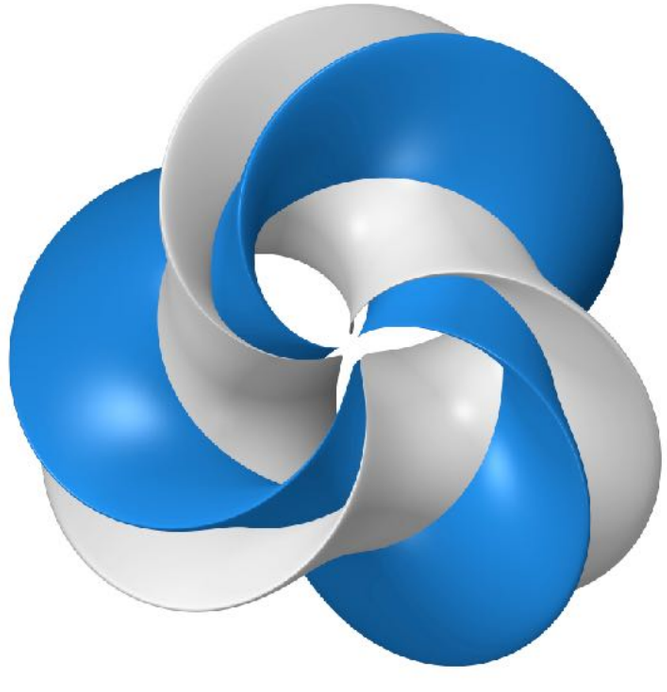


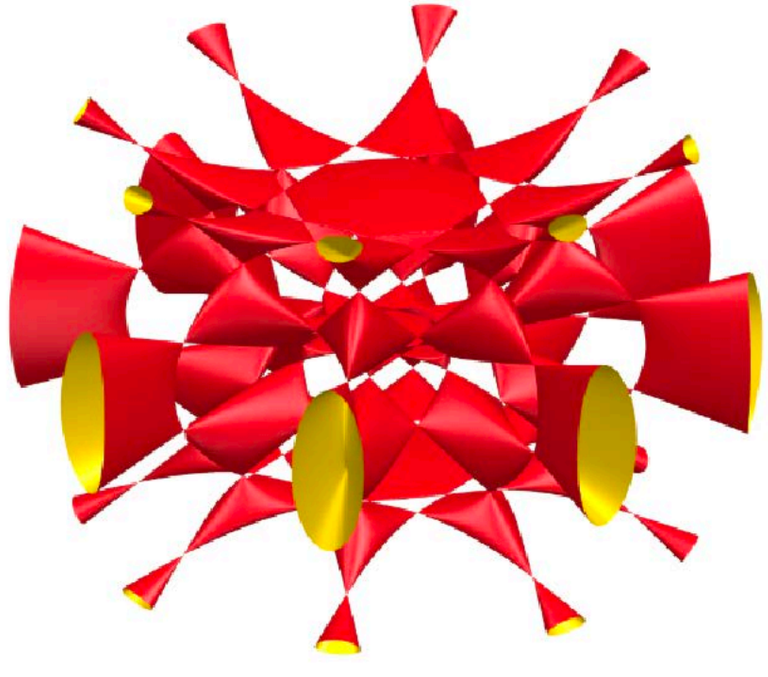
(x^2+9/4·y^2+z^2−1)^3−x^2·z^3−9/80



x^3+x^2·z^2−y^2







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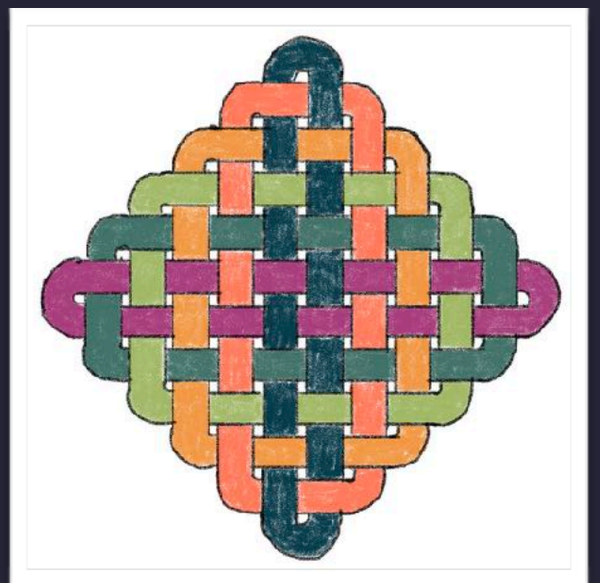
#MathArtChallenge

@KjerstiFried

@RosieTChen

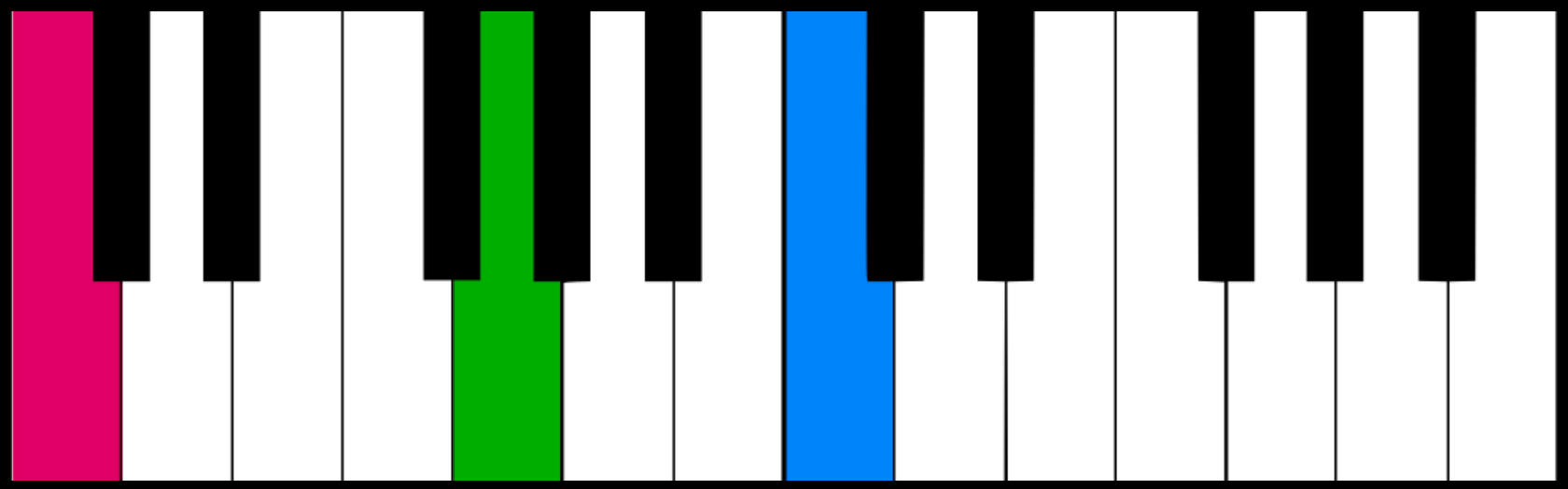


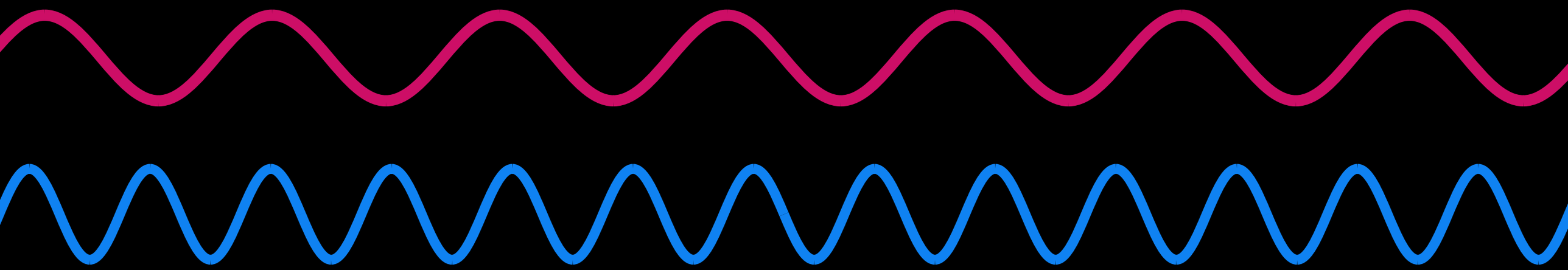
@jayproffitt

@anniek_p

@Cshearer41

@bquentin3





$\sqrt[12]{2}$ 1.4983... ≈ 1.5

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imaginary.github.io/web-hexachord/

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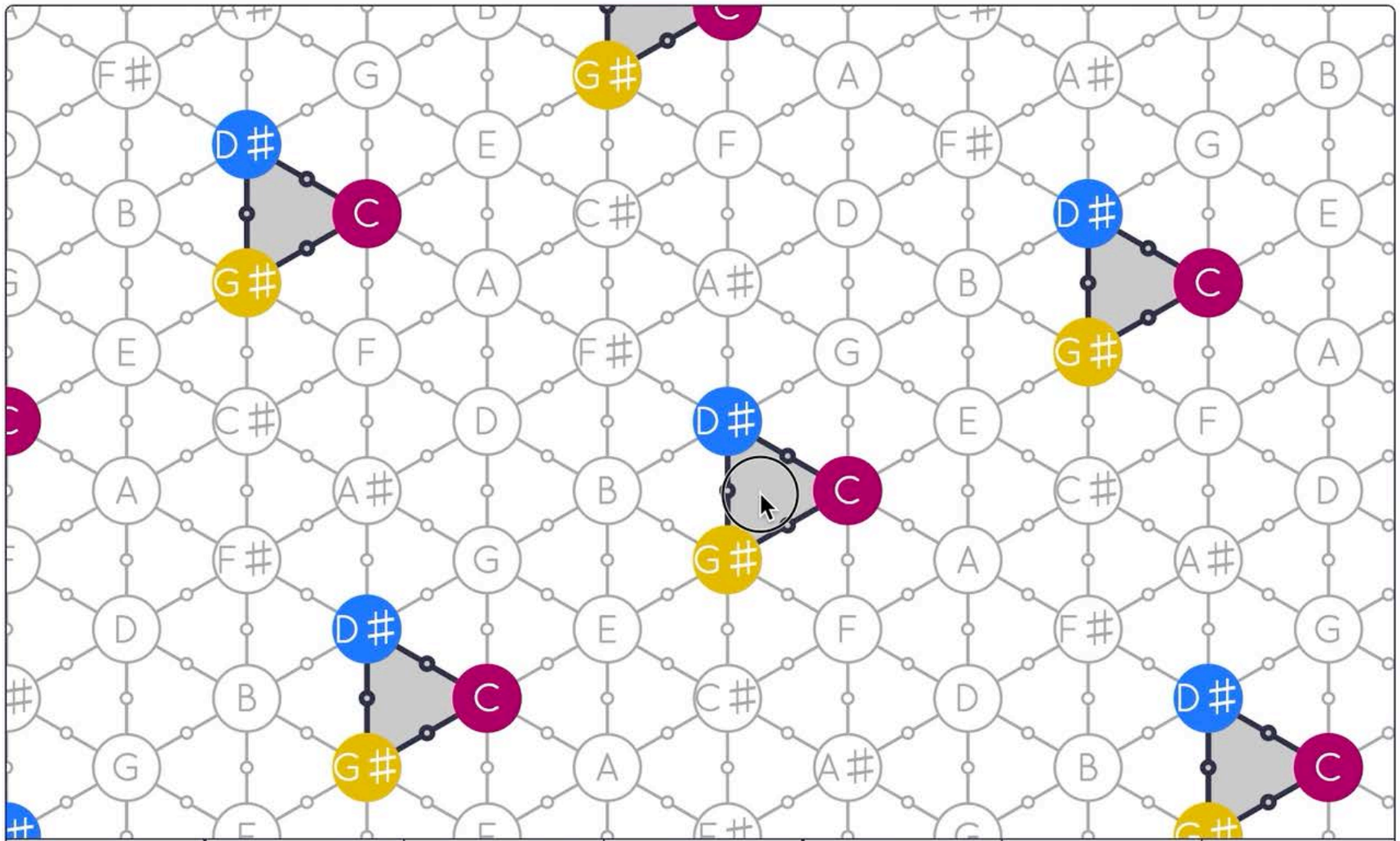

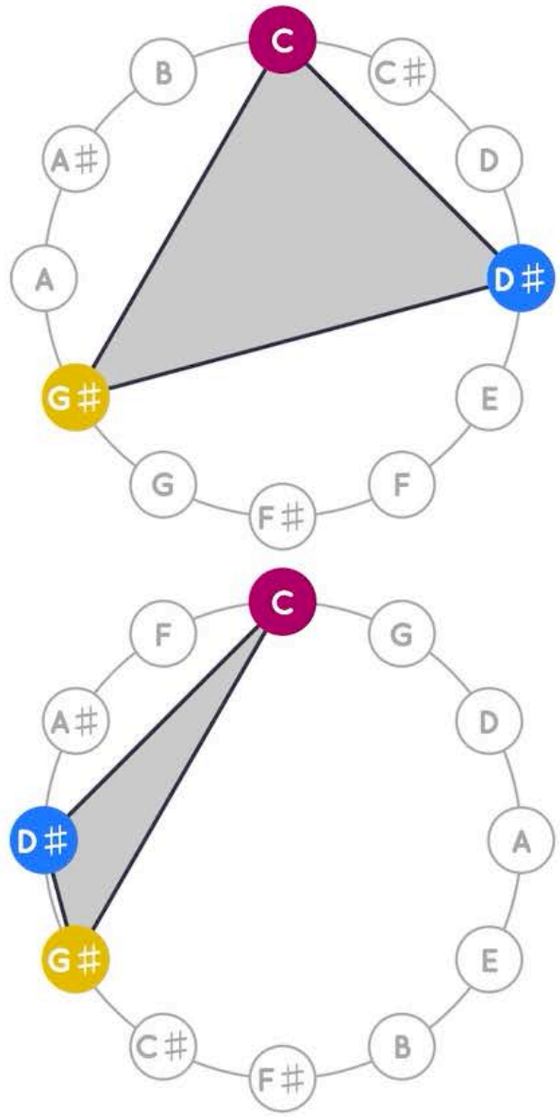

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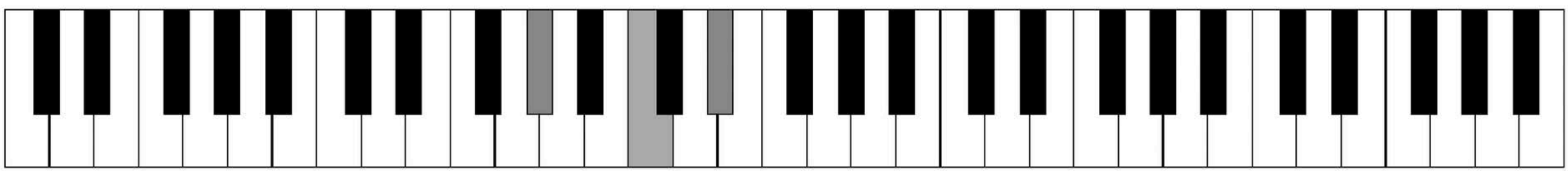

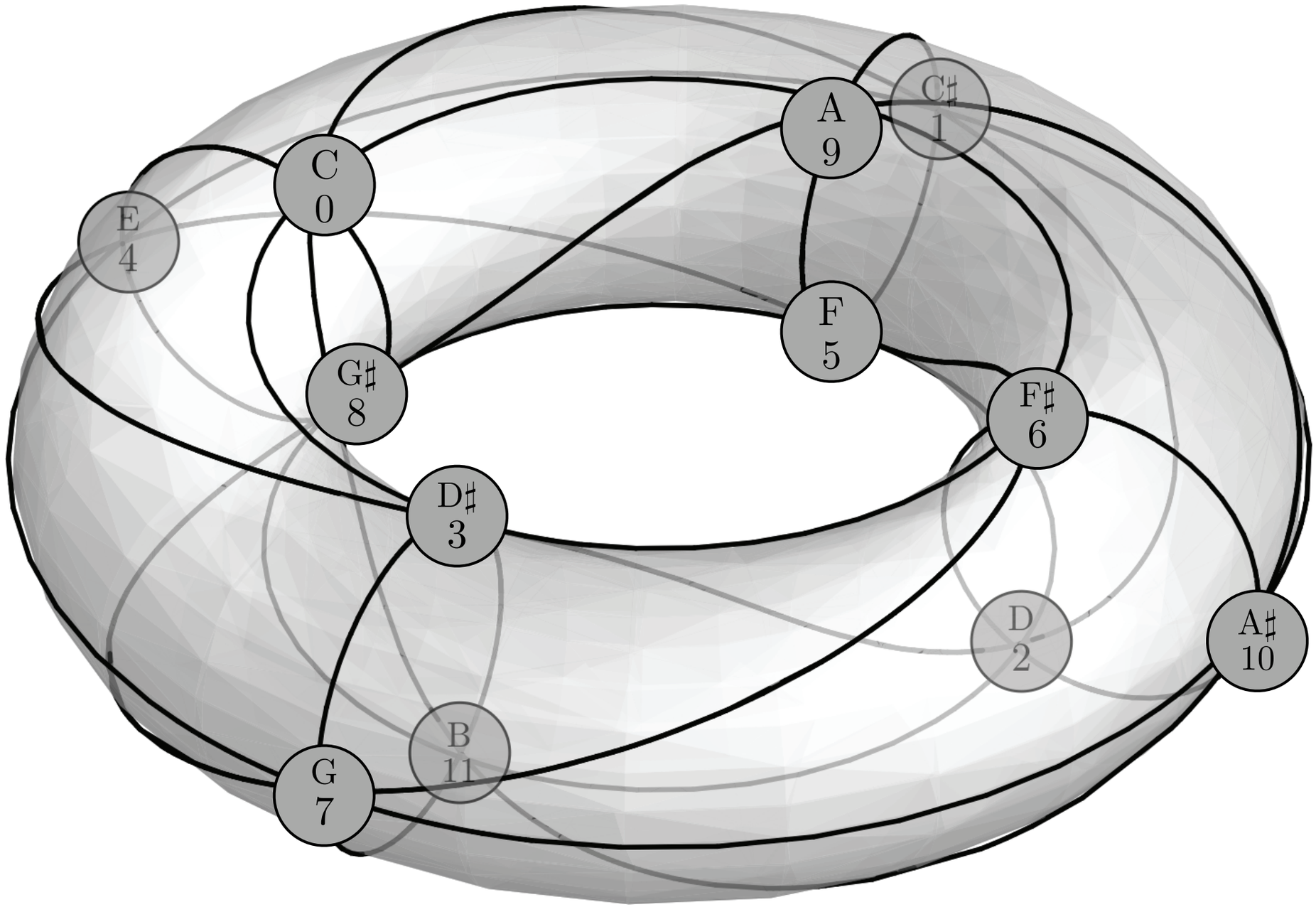
C
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6
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G♯
8
A
9
A♯
10
B
11

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Creativity is Problem Solving!

Reduce complex problems to their essentials and discover patterns.

Express situations using new or different representations.

Recognise implicit assumptions and think outside the box.

Combine tools and results from different parts of mathematics.

You break a stick in two different places, uniformly at random. What is the probability that the three resulting pieces form a triangle?

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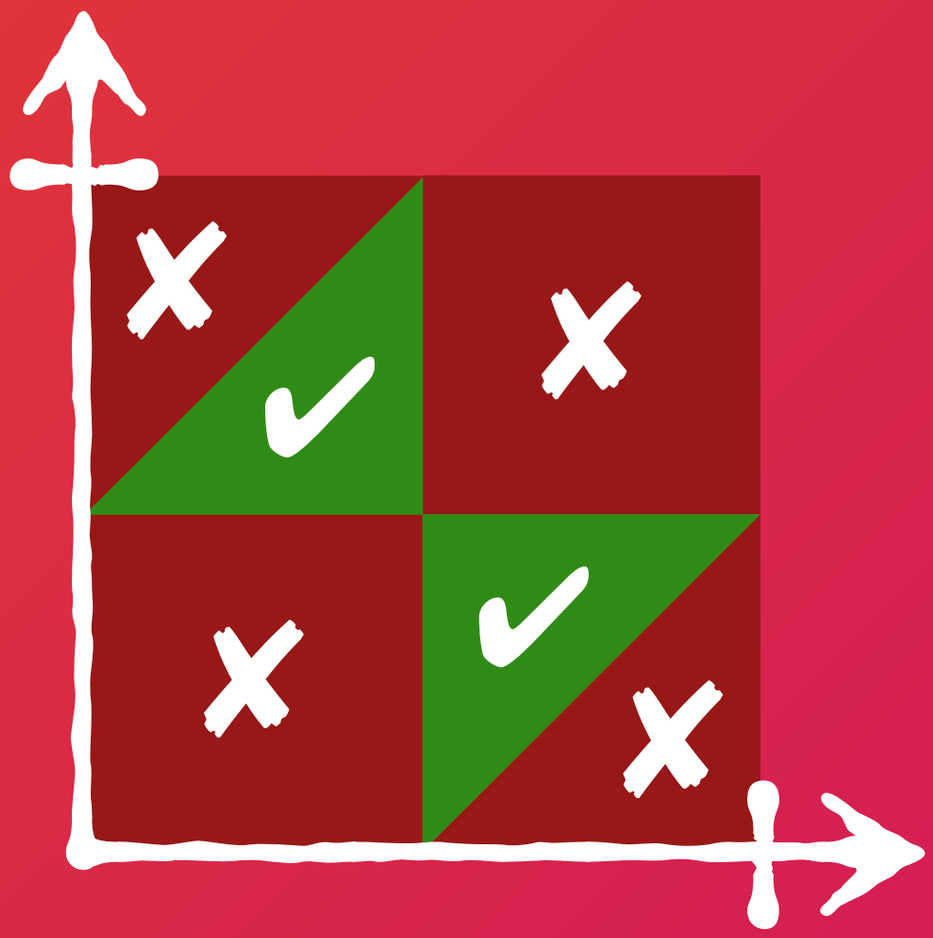

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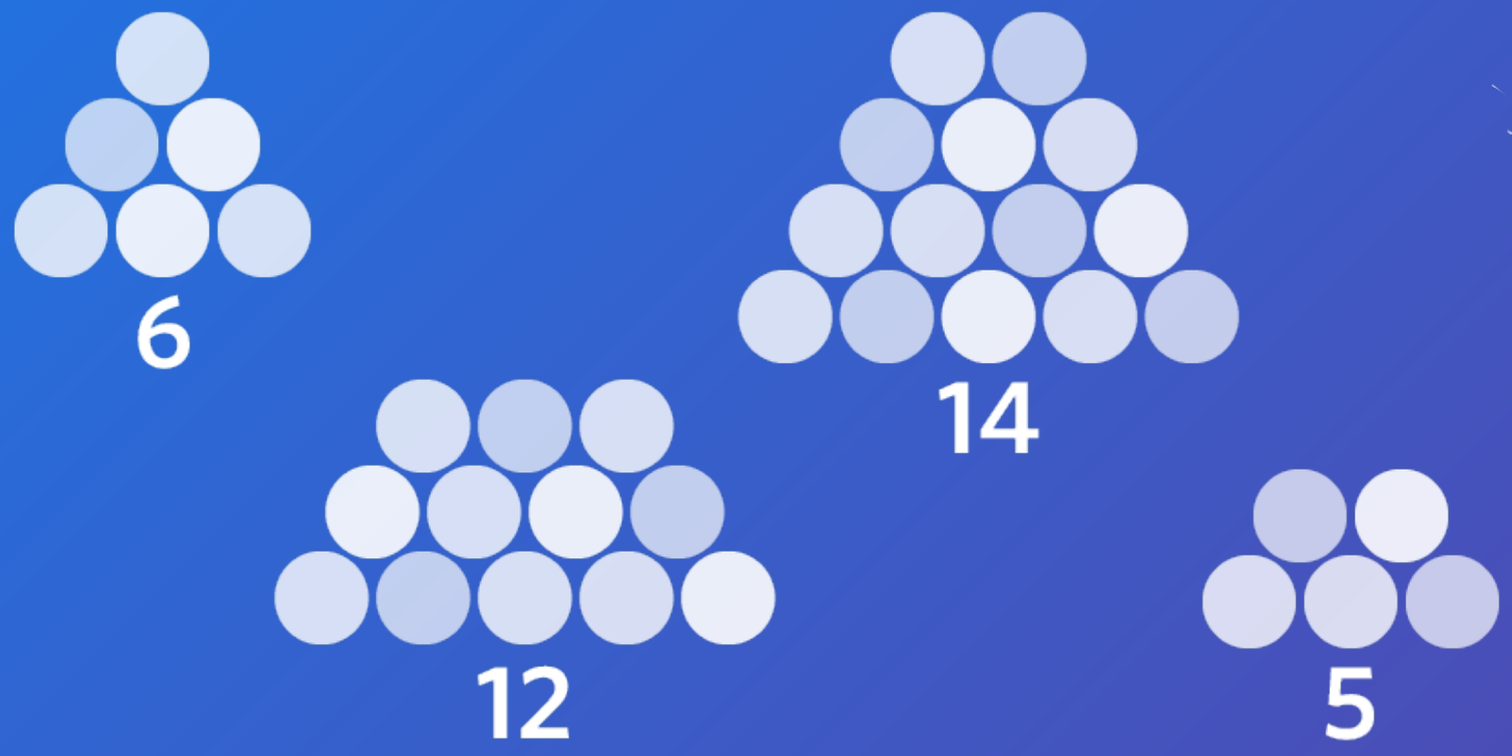
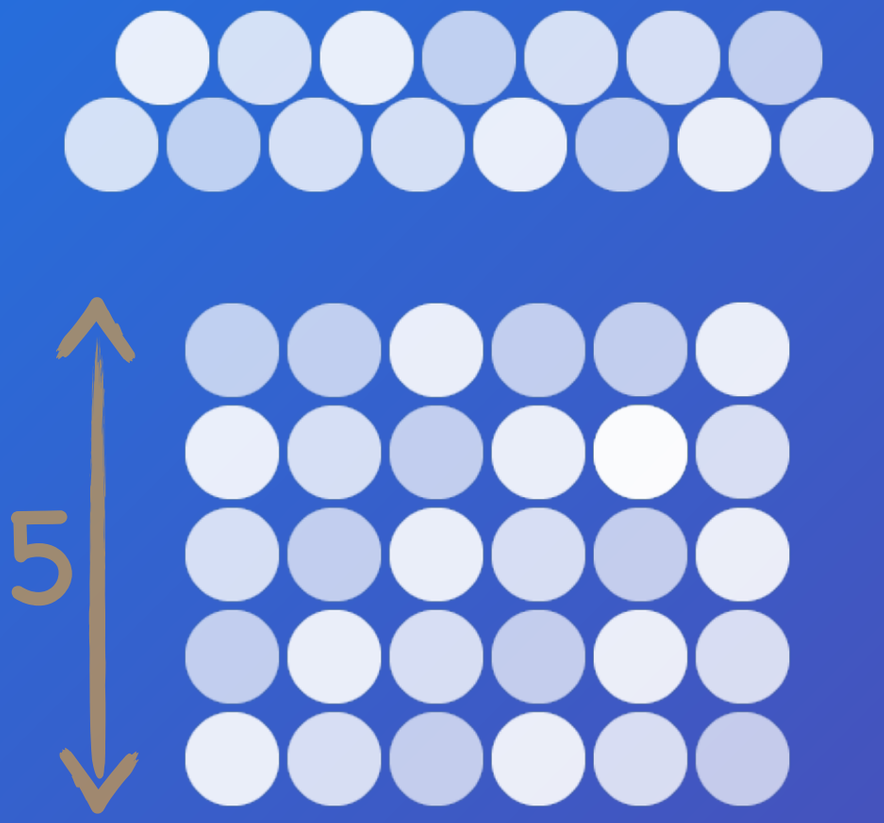


Here are some *Trapezium Numbers*. There is just one number between 1000 and 2000 that *doesn't* form a Trapezium. Which one?



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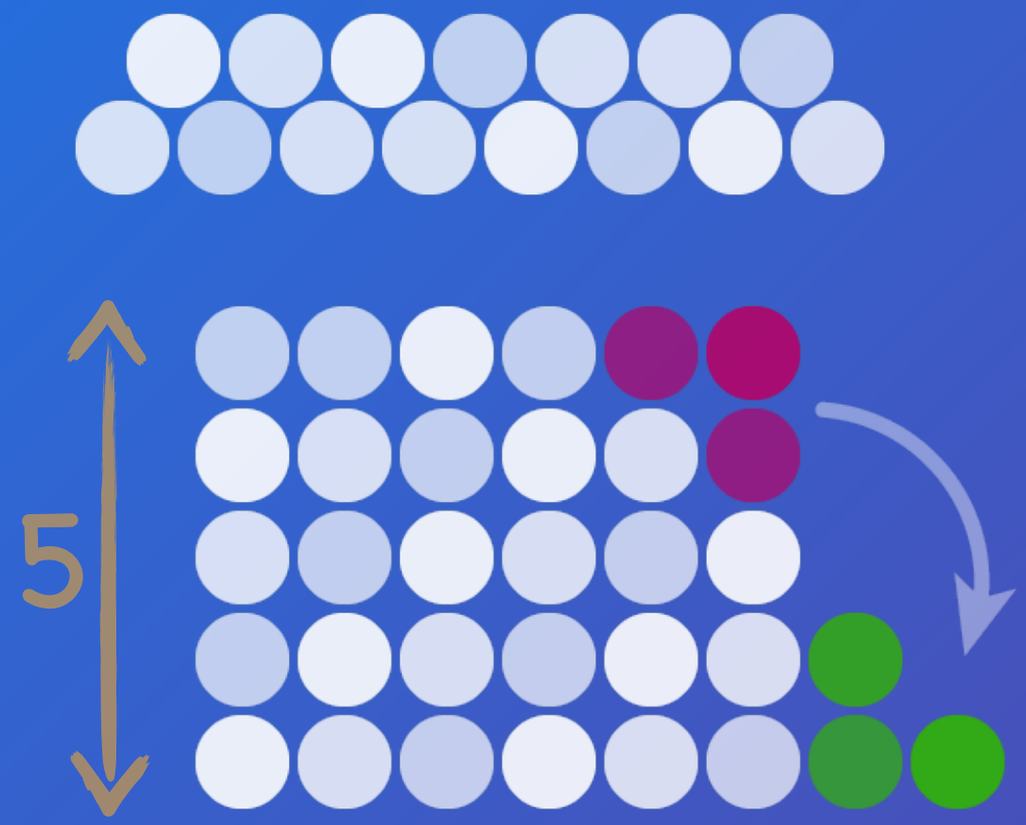

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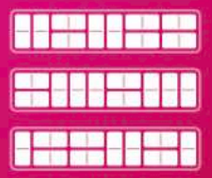
mathigon.org/puzzles

1

How many ways are there to tile a rectangle of size 2×10 with dominoes?



2

A semicircle lies inside a square. What proportion of the square is shaded?

3

There are 20 strings in a bag. You randomly pick two ends and tie them together, until there are no free ends left. What is the expected number of loops you will create?

4

Rearrange these numbers and symbols to make a true equation:

2 3 4
5 + =

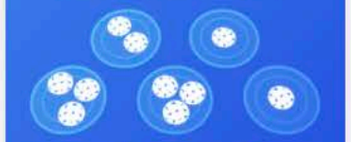
5

What is the least number of integers needed, so that any of these could be true?

Median < Mean < Mode
Median < Mode < Mean
Mode < Median < Mean
Mode < Mean < Median
Mean < Mode < Median
Mean < Median < Mode

6

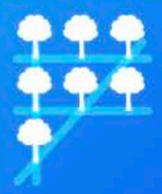
How many ways are there to distribute 10 identical cookies between five different kids?



Kids don't need to receive the same number of, or any, cookies.

7

Can you plant 7 trees so that there are 6 straight lines containing 3 trees each?

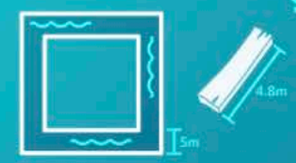


8

$$x^{x^{x^{x^{\cdots}}}} = 2$$

What is the value of x?

9



A castle is surrounded by a 5 meter wide, rectangular moat. Can you cross it using nothing except two planks that are 4.8 meters long?

10

I repeatedly toss a fair coin and record the outcome. What is the probability that the sequence "HHH" occurs before "THH"?

11

Every frog jumps into an adjacent square (left, right, up or down). What is the largest number of squares that could become empty?

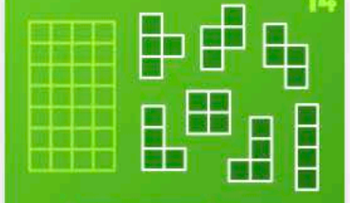
12

Can the locomotive *L* switch the position of the two wagons and end up where it started? Only the locomotive can fit under the bridge.

13

You have 10 cans of peas. All peas weigh 1 gram, except for one can with peas that weigh 0.9 grams. How often do you need to use a scale to find this lighter can?

14



Can you arrange the seven Tetrominoes in a 7×4 rectangle, with no gaps or overlaps?

15

Scientists are studying a micro-organism, starting with a single cell. Every day, each cell either splits in two (with probability p), or it dies. What is the probability that the entire organism dies eventually?

16

Continue this sequence:

6 10 14 15
21 22 26 33
34 35 ? ?

17

What's the angle between these congruent equilateral triangles?

18

Three geysers A, B and C in a national park erupt every 1, 2 and 3 hours respectively. You just arrived: what is the probability that you will see geyser A erupt first?

19

Can you place 18 black and 18 white tiles on a 6×6 board, so that there are no "squares" with their four corners having the same colour?

20

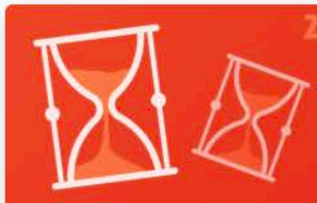
What 4-digit number, when multiplied by 4, reverses its digits?

$$ABCD \times 4 = DCBA$$

21

What proportion of a square is closer to its centre than its edge?

22



Can you measure exactly 15 minutes using nothing but an 11-minute hourglass and a 7-minute hourglass?

23

You pick three random points on a circle. What is the probability that the resulting triangle contains the center of the circle?

24

This is the most efficient way to place three congruent squares in an equilateral triangle. What proportion of the triangle is shaded?

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Resources

parallel
by Simon Singh

Philipp Legner
Year 7 • Edit Account • Logout

WEEK 15
Blackboard Equation

WEEK 14
Sumaze

WEEK 13
Good Will Hunting

WEEK 12
Maths Jokes

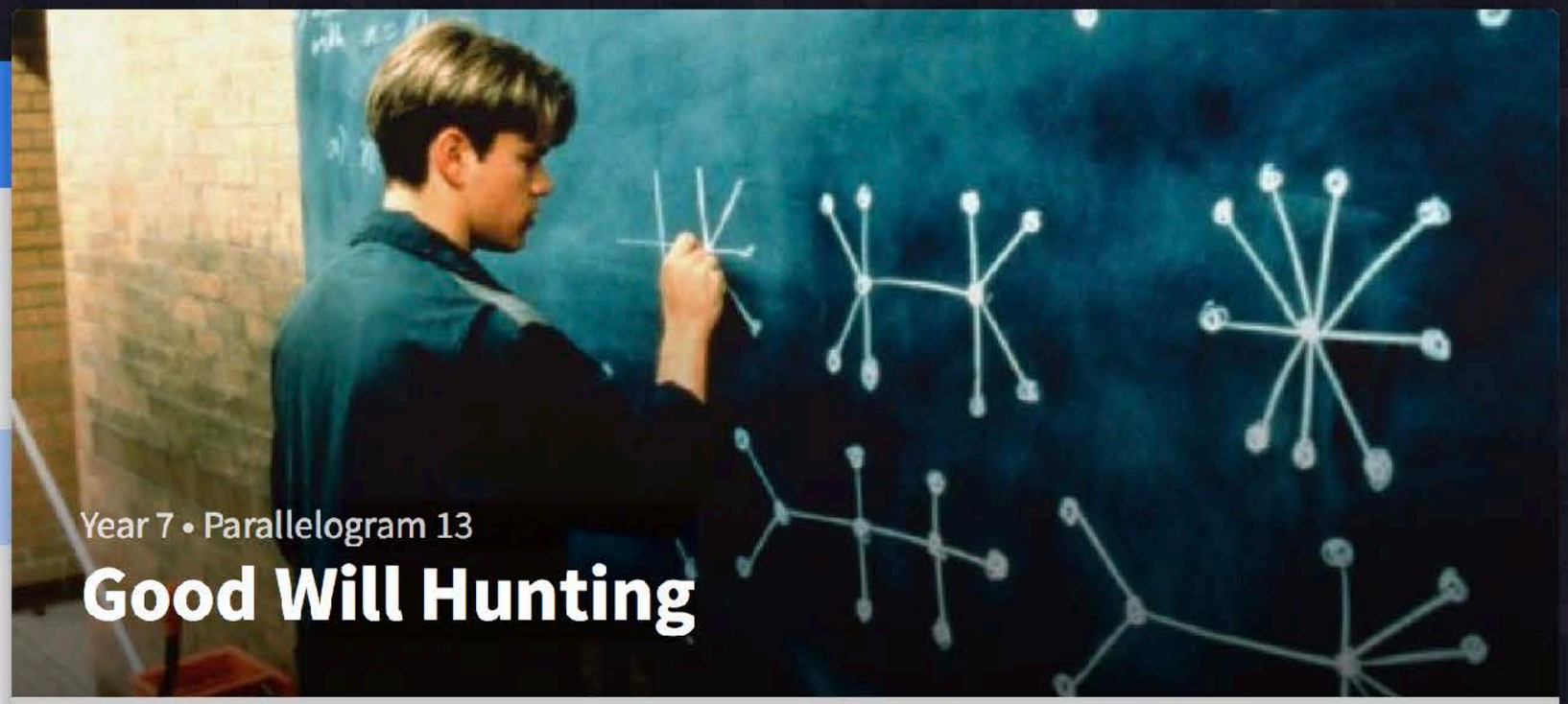
WEEK 11
The Secret of Happiness

WEEK 10
A matter of factorial!

WEEK 9
Easter challenges

WEEK 8
Tricky parking problem

WEEK 7
Optimising your pizza money



Year 7 • Parallelogram 13

Good Will Hunting

Noun: Parallelogram **Pronunciation**: /ˌparəˈlɛləgram/

1. a portmanteaux word combining parallel and telegram. A message sent each week by the Parallel Project to bright young mathematicians.

There are only 3 more Parallelograms this year, as we will be starting our summer break at half-term. If you score highly enough in the last 4 Parallelograms (#12, this one, #14 & #15) by June 1, **then you will receive a Parallel certificate**. An average of more than 40% in these four Parallelograms wins a bronze certificate, then 60% or more wins silver

Welcome to the home of rich mathematics

Teachers

Free resources and curriculum mapping documents

Early Years
Primary
Secondary, Post 16 and STEP

Primary Pupils

The tasks in this feature encourage you to play and explore, then think deeply about the mathematical ideas underneath.

See all problems Open for Solution
See all Resources for ages 5-11

Secondary Students

In this feature, explore the problems and then try to explain what's going on!

See all problems Open for Solution
See all Resources for ages 11-18

Events and PD

Your Solutions

Tweets by @nrichmaths

NRICH maths Retweeted

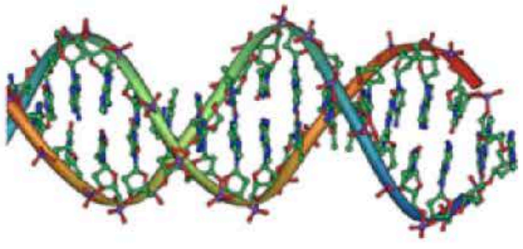
Liz Woodham
@emw1001

First day of @nrichmaths PD with a new group of primary teachers from Tower Hamlets. Six days focusing on whole class reasoning. And I get to work with @FranMaths too. Woo hoo

Welcome To Plus Magazine!

Welcome to the FIFA World Cup!

From making penalties fairer or taking the perfect free kick, to designing an ideal ball and predicting results using an octopus, it's all there in our collection of football articles. Take your pick!



Genetics: Nature's digital code

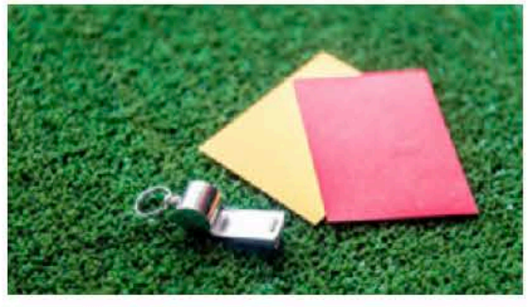
Is nature using digital tools to deal with genetic information?

Maths in a minute: Chomp

Explore a game that involves biscuits and comes with a surprising mathematical twist — what could be better?

The real numbers and Cauchy sequences

We take the real numbers for granted, but what are they really? Here's an interesting way



Clocking the schedule

The way many football leagues schedule their fixtures can lead to unfair effects — and unsolved maths problems! Dries

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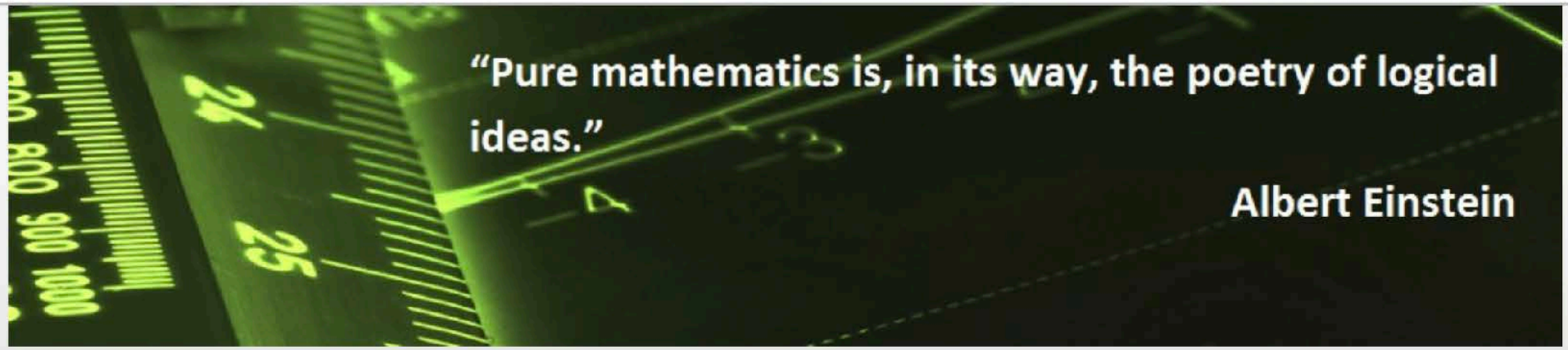
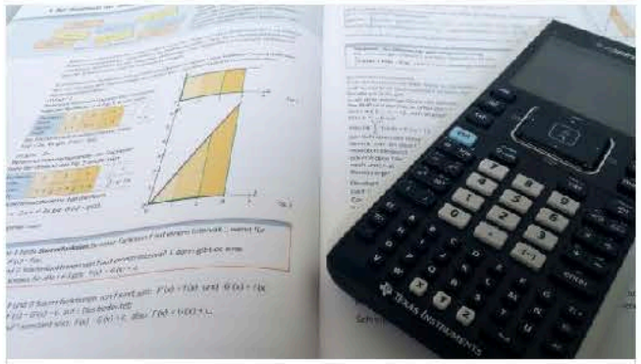


Featured Articles



Which Degree Courses need A-level Mathematics?

A-level Mathematics is one of the most widely accepted and respected subject choices by universities. Read about how it can enhance your course options.

Read the full

Recent Articles

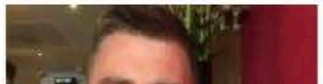
Joint degrees including mathematics

Choosing what to study at university can be hard. Lots of students choose to study joint degrees, where they study more than one subject.

Featured Profiles

Depaak Mahta - Data Scientist and Community manager

Read the full profile



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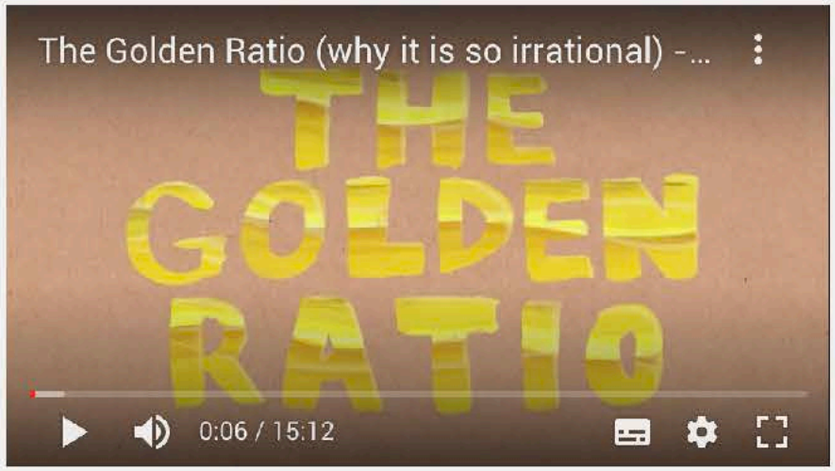

The Golden Ratio (why it is so irrational) - Numberphile

2,398,250 views • 1 year ago

Check out Brilliant (and get 20% off) by clicking
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Golden seeds limited edition T-Shirt:
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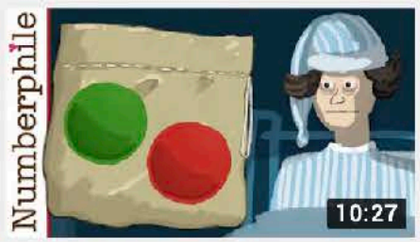
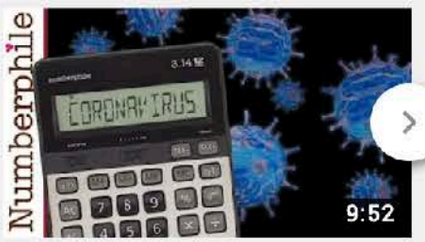


Lewis Carroll's Pillow

Why is this Puzzle

The Daddy of Big Numbers

Impossible Squares -



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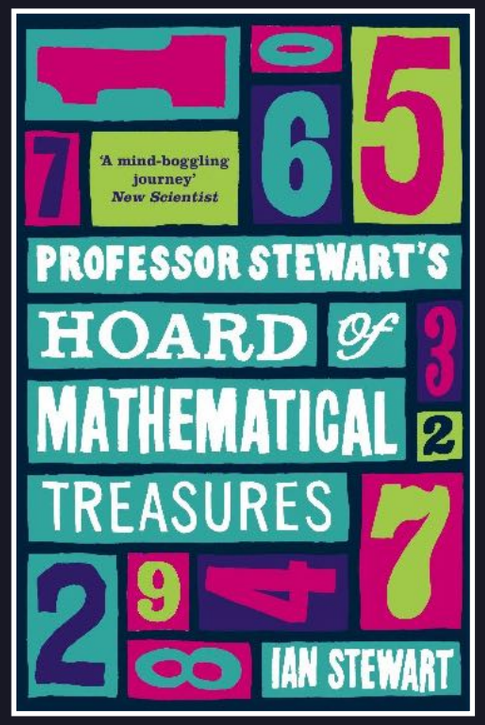
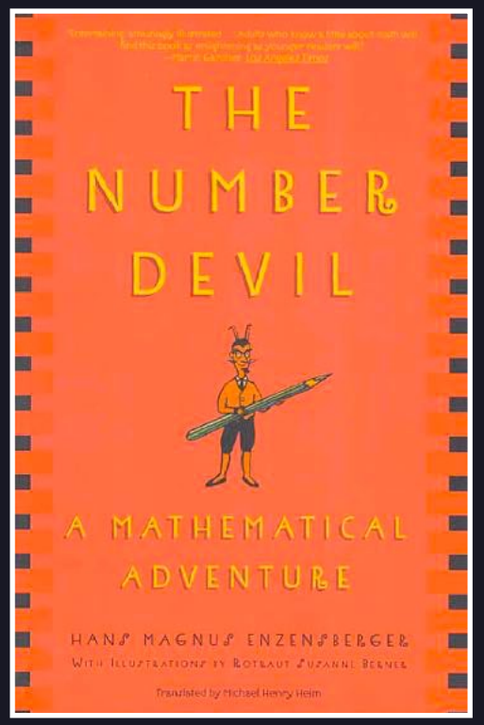
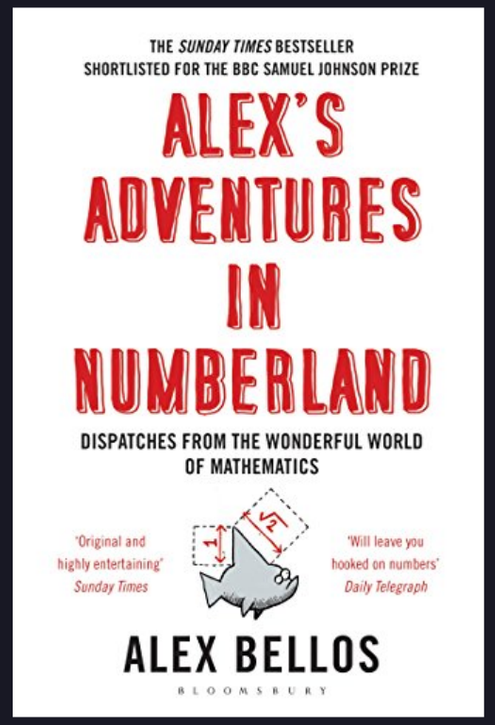
Popular Mathematics Books



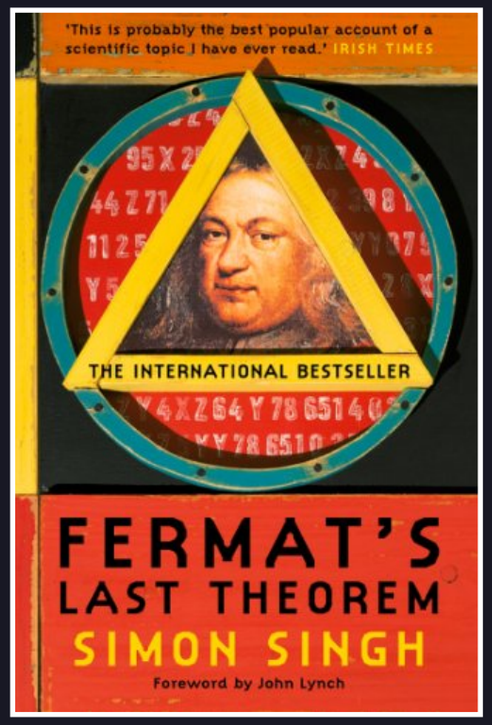
Ian Stewart



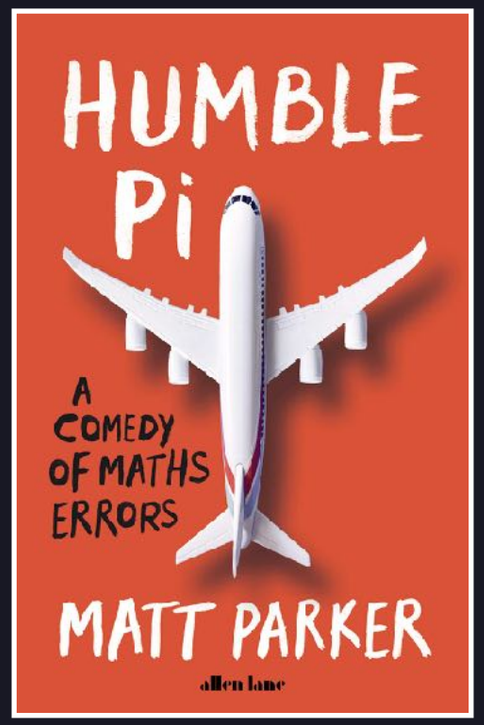
Hans Magnus Enzensberger



Alex Bellos

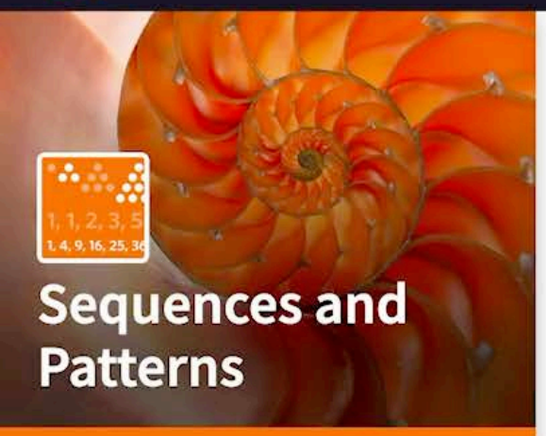


Simon Singh

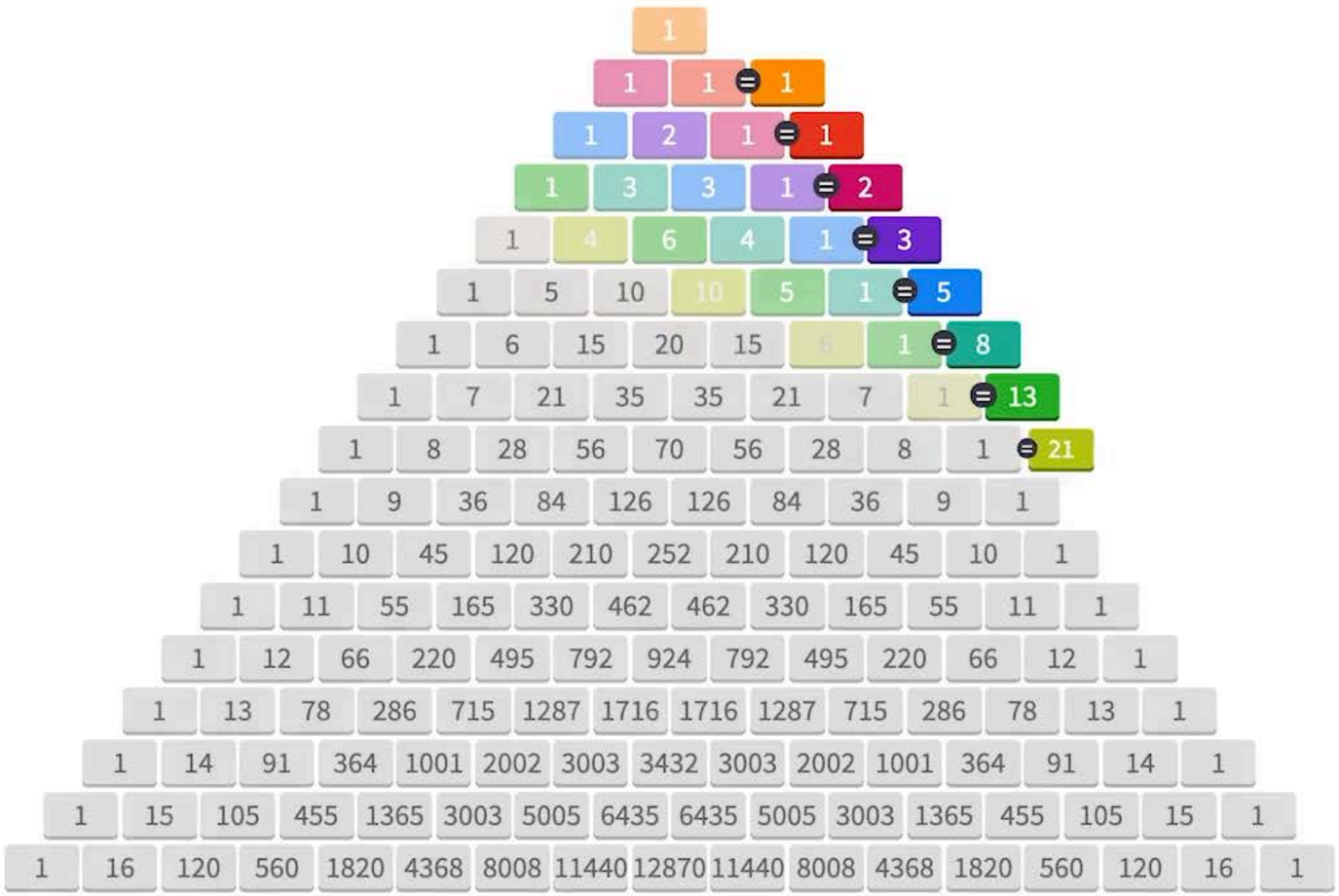


Matt Parker

Mathigon



Sequences and Patterns



The diagram above highlights the "shallow" diagonals in different colours. If we add up the numbers in every diagonal, we get the ???.

Nice!

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Thanks for listening!

philipp@mathigon.org

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